ISO TC 184/SC4/WG3 N933

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ISO/WD Validation Report on ISO/IS 10303-214

ABSTRACT:

AP214 'Core Data for Automotive Mechanical Design Processes' Validation Report for the FDIS/IS version with the number ISO TC184 SC4 WG3/N931.

KEYWORDS:

Application Protocol, automotive, mechanical design, validation report

COMMENTS TO READER:

This document is the nineth edition of the validation report of AP214. It supports the IS version of AP214.

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1 Introduction

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

A fundamental concept of ISO 10303 is the definition of application protocols (AP) as the mechanisms for specifying information requirements and for ensuring reliable communication. An application protocol is a part of ISO 10303 that defines the context, the scope, the information requirements for designated application(s), the constructs of the integrated resources used to satisfy these requirements, and specifies the conformance requirements for conformance testing of implementations of the AP.

This document is the AP validation report for AP214 'Core data for Automotive Mechanical Design Processes' that addresses the requirements of the automotive industry. This application protocol supports various development stages during the design of a technical product.

The AP validation report is maintained during the development of the AP as a supporting document. The basic concept of AP validation is to ensure that the scope and information requirements are completely and unambiguously delivered in the AP. This requires that the scope, requirements, application reference model (ARM), application interpreted model (AIM), and conformance requirements are complete and consistent. Therefore the overall validation process includes

- a validation for the ARM with connection to the Application Activity Model (AAM),
- an AIM and ARM to AIM mapping (interpretation) validation,
- a review of the conformance requirements as well as test purposes and
- validation through prototype implementations.

This validation and reviewing is mainly done by expert discussions and case studies using real world examples provided by the users from different companies and countries. Real world examples have been also the basis for the testing of prototype implementations, where different groups of units of functionalities (UoF) of the AP214 have been evaluated.

As the validation process is completed parallel to the development of the application protocol, the structure and the completion of this document is in accordance with the development and advance of the specification of the AP214 document and related documents like the abstract test suite ATS314.

In Table 1-1 the tasks, methods, and responsibilities of the validation process is shown. The structure of the validation report documentation can be derived analogous.

	Task	**Method**	**Responsibility**
1	Scope and requirements validation	Validation workshops: Expert discussions on scope and requirements	application experts
2	ARM validation	Validation workshops: Expert discussions on ARM and harmonization	application experts, experts in modeling methodology
		mapping of real world examples	application experts
3	AIM validation	mapping workshops and review AIM and mapping table	implemention experts, experts in modeling methodology
		feedback from prototype implementations	implementation experts
4	Conformance requirements and test purpose validation	expert discussions on conformance requirements and test criteria	application and implementation experts
5	Prototype implementations	testing of prototypes by real world examples	application and implementation experts

Table 1-1: Tasks of the validation process

2 AP Validation Plan

2.1 Validation Workshops

For the validation of the scope, the ARM, the conformance requirements, and the ARM to AIM mapping (interpretation) there have been several validation workshops on three organizational levels. The organizational levels for the validation are:

- ISO TC184 SC4 expert meetings: At these meetings validation topics from all points of view are discussed, e.g. user, modelling, as well as implementation aspects. Another important topic on this level is the harmonization of requirements, interpretation, and AIM with other overlapping AP projects. The participants are representatives from users, system vendors, associations and research institutes.

- For the validation of the interpretation and interoperabilty requirements there were specific workshops with STEP and user experts arranged, additional to the discussions at the ISO TC 184 SC4 WG meetings.
- International automotive expert meetings: These meetings focus on user requirements. The scope, ARM, and ARM to AIM interpretation have been significantly influenced and validated by the technical discussions by the attending experts representing companies of the following automotive industry associations
  - Automotive Industry Action Group (AIAG); USA
  - Groupement pour l'Amelioration des Liaisons dans l'Industrie Automobil (GALIA); France
  - Japan Automobile Manufacturers Association (JAMA); Japan
  - Organisation for Data Exchange by Tele Transmission in Europe / Sweden (Odette-Sweden) ; Sweden
  - Verband der Automobilindustrie (VDA); Germany
- Expert meetings of national AP214 development teams: All listed automotive industry associations have established teams and projects within their organization for supporting the AP214 development. Among other topics related to the AP214 development all aspects of AP validation have been considered by these teams.

For example in Germany there was an infrastructure established to support the development of AP214. On the one hand there were projects defined in the German automotive industry to fund the development of AP214, i.e. the ProSTEP Project (1991 to 1993), the STEP/PDMI Project (1994 to 1996), and the PDMI2 Project (1997 to 1999). These projects provided a plattform for the expert discussions and validation of users from automotive companies. On the otrher hand there are working groups organized within the VDA and ProSTEP Association for the validation of AP214 for specific applications - i.e. Kinematics, FEA, Administrative Product Data - and with regard to the requirement of interoperability to overlapping APs.

Table 2-1 shows a list of the expert meetings on the level of ISO TC184 SC4. The following companies/organizations attended these meetings and delivered comments on AP214 validation on a regular basis:

AIAG, USA
Adam Opel AG, Germany
Audi AG, Germany
Ausdec, Australia
Bentley Systems, USA
BMW AG, Germany
Boeing Corp., USA
Chrysler Corp., USA
CIMIO, England
Concurrent Technologies, USA
Daimler Benz AG, Germany
debis Systemhaus, Germany
DiK (TH Darnmstadt), Germany
EDS GmbH, Germany
EuroSTEP GmbH, Germany
Ferroday, U.K.
Fiat Auto, Italy
Ford Motor Co., USA
GALIA, France
General Motors, USA
GfS GmbH, Germany
GOSET, France
Grumman Data Systems, USA
Hewlett-Packard GmbH, Germany
Honda Co. Ltd., Japan
Hughes Aircraft Corp., USA
IBM, USA
ICEM Systems, USA
ISI-Dentsu, Japan
ITI-Ohio, USA
IVECO FIAT S.p.A., Italy
IVF, Sweden
JISC, Japan
KAIST, South Korea
MCS Inc., USA
Mercedes-Benz AG, Germany
Mitsubishi Heavy Industries Ltd., Japan
National Research Council, Canada
Nissan Motor Co., Japan
PDES, Inc., USA
ProSTEP GmbH, Germany
PSA - Peugeot Citroen, France
QuantumSTEP, U.K.
Renault, France
RPK (Universität Karlsruhe), Germany
Scania, Sweden
SI Senter for Industriforskning, Norway
Siemens AG, Germany
Toyota Motor Corp., Japan
Unigraphics Solutions, USA
UNINFO, Italy
UTC/Pratt&Whittney, USA
Volkswagen AG, Gernany
Volvo Corp., Sweden

Table 2-1: Expert meetings on the level of ISO TC184 SC4

Organization	Meeting	Date	AP214 Version	Topic
ISO TC184 SC4 WG3/T19	Seattle, USA	4/1992	-	Scope, Project Plan
ISO TC184 SC4 WG3/T19, T18	London, U.K.	7/1992	-	Scope, AAM, ARM structure
ISO TC184 SC4 WG3/T19, T18	Dallas, USA	10/1992	-	AAM, ARM, UoF
ISO TC184 SC4 WG3/T19, T18	Turino, Italy	2/1993	WG3/N215	AAM, ARM, UoF
ISO TC184 SC4 WG3/T19, T18	Atlanta, USA	6/1993	WG3/N228	AP harmonization, AAM, ARM

Organization	Meeting	Date	AP214 Version	Topic
ISO TC184 SC4 WG3/T19, T18	Berlin, Germany	10/1993	WG3/N246	ARM validation, ARM, AP harmonization, UoF
ISO TC184 SC4 WG3/T19, T18, T4, T7, T11	Phoenix, USA	1/1994	WG3/N268	ARM validation, ARM, AP harmonization
ISO TC184 SC4 WG3/T19, T18	Davos, Switzerland	5/1994	WG3/N297	ARM (Form Features, Process Plans), AP harmonization, CC
ISO TC184 SC4 WG3/T19, T18, T4, T7, T11	Greenville, USA	10/1994	WG3/N268	ARM validation, ARM, AP harmonization
ISO TC184 SC4 WG3/T19, T7	Sydney, Australia	3/1995	WG3/N398	AP harmonization (AP224)
ISO TC184 SC4 WG3/T19, T7, T9	Washington, USA	6/1995	WG3/N411	ARM (Form Features, Product Structure), AP harmonization (AP202, AP209, AP224, TDP), AIC
ISO TC184 SC4 WG3/T19, T4, T7, T9, T11	Grenoble, France	10/1995	WG3/N454	ARM (Form Features, Product Structure, Tolerances, Materials, FEA), AP harmonization (AP202, AP224, TDP), AIC
ISO TC184 SC4 WG3/T19, T9	Dallas, USA	1/1996	WG3/N469	CD issues, AP harmonization (AP202, AP209, AP224), AIC
ISO TC184 SC4 WG3/T19, T1, T7, T9, T11	Kobe, Japan	6/1996	WG3/N509	AP harmonization (AP212, AP223, AP224, AP229, TDP), AIC
ISO TC184 SC4 WG3/T19, T7, T11	Toronto, Canada	10/1996	WG3/N536	AP harmonization (AP212, AP221, AP224),AIC, Mapping
ISO TC184 SC4 WG3/T19, T7, T11	Chester, U.K.	3/1997	WG3/N577	AP harmonization (AP212, AP221, AP224, AP232),AIC, Mapping
ISO TC184 SC4 WG3/T19	Florence, Italy	10/1997	WG3/N578	Issue Resolution
ISO TC184 SC4 WG3/T19	Orlando, USA	2/1998	WG3/N578	Issue Resolution, ARM, AP harmonization
ISO TC184 SC4 WG3/T19	Bad Aibling, Germany	6/1998	WG3/N578	Issue Resolution, ARM, AP harmonization, AIC, Mapping

Table 2-2: ISO expert meetings

Table 2-4 shows a list of the expert meetings of the international automotive industry organizations. The following companies/organizations attended these meetings and delivered comments on AP214 validation on a regular basis:

AIAG, USA
BMW AG, Germany
Chrysler Corp., USA
Daihatsu, Japan
Daimler Benz AG, Germany
debis Systemhaus GmbH, Germany
DiK (TH Darmstadt), Germany
EDS GmbH, Germany
EuroSTEP GmbH, Germany
Ford Motor Co., USA
GALIA, France
General Motors/EDS, USA
GOSET, France
Grumman, USA
Hino motors Ltd., Japan
Honda, Japan
Industrial Technology Institute (ITI), USA
Isuzu, Japan
Kawasaki, Japan
Keiper Recaro, Germany
Lockheed Martin, USA
Mazda, Japan
Mercedes-Benz AG, Germany
Mitsubishi Motors Corp., Japan
Nissan Motor Co., Japan
PDES Inc., USA
PSA - Peugeot Citroen, France
ProSTEP GmbH, Germany
Renault, France
Rockwell, USA
Scania, Sweden
Toyota Motor Corp., Japan
Volkswagen AG, Gernany
Volvo Corp., Sweden
Yamaha, Japan

Table 2-3: Attendees on expert meetings of the international automotive industry organizations

Organization	Meeting	Date	AP214 Version	Topic
ProSTEP/PRODEX/ INTERROB	Germany	4/1993	WG3/N215	ARM, UoF
AIAG/VDA-Workshop	Detroit, USA	5/1993	WG3/N228	Scope, ARM, AP interoperability
JAMA/VDA-Workshop	Tokyo, Japan	5/1993	WG3/N228	Scope, AAM, ARM
JAMA/GALIA/VDA-Workshop	Berlin/Wolfsburg, Germany	11/1993	WG3/N246	AAM, ARM
AIAG/VDA-Workshop	Southfield, USA	3/1994	WG3/N268	CC, ARM (Versioning Concepts, Process Plan, Surface Conditions, Materials, Form Features)
AIAG/JAMA/GALIA /VDA-Workshop	Tokyo, Japan	4/1994	Tokyo0494	ARM (Product Structure, BOM, FEA, Tolerances, Draughting, Presentation), CC
AIAG/JAMA/GALIA /VDA- Workshop	Paris, France	9/1994	WG3/N331	ARM (Product Structure and Configuration, Process Plan, Draughting, Presentation, Properties, Surface Conditions, FEA, Kinematics, Form Features), CC
AIAG/JAMA/GALIA /VDA- Workshop	Darmstadt, Germany	12/1994	Darmstadt_ 1194	ARM (Product Structure, Form Features)

Organization	Meeting	Date	AP214 Version	Topic
GALIA/VDA Workshop	Paris, France	2/1995	WG3/N371	ARM (Product Structure, Configuration)
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Stuttgart, Germany	3/1995	WG3/N398	ARM (Product Structure, Form Features)
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Detroit, USA	5/1995	May 2, 1995	ARM (Product Structure, Form Features, Tolerances, Process Plan, Kinematics, FEA, Properties, Geometry, Surface conditions), CC
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Paris, France	10..11/1995	WG3/N454	ARM (Product Structure, Form Features, Tolerances, Process Plan, Kinematics, FEA, Geometry, Presentation), CC, AP harmonization, Mapping
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Detroit, USA	1...2/1996	WG3/N469	CD issues (ARM, CC, Mapping), AP harmonization
AIAG/JAMA/VDA-Workshop	Darmstadt, Germany	5/1996	May 4, 1996	ARM (Product Structure, Geometry, Properties, FEA), AP harmonization (AP209), Mapping
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Hiroshima, Japan	6/1996	WG3/N509	ARM (Product Structure, Geometry, Presentaion, Draughting, Form Features, Tolerances, Surface Conditions, Kinematics,Properties, External References), CC, AP harmonization, Mapping
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Darmstadt, Germany	8/1996	July 15, 1996	ARM (Product Structure, External References, Form Features, Properties, Process Plans)
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Gothenburg, Sweden	10/1997	WG3/N578	CD2 Issue Resolution
AIAG/JAMA/GALIA /Odette-SWE/VDA-Workshop	Detroit, USA	2/1998	March 02, 1998	Final Issue Resolution Discussion in S7 area

Table 2-4: Expert meetings of the international automotive industry companies

The expert meetings of the German AP214 development projects started in 1991. The experts are meeting periodically every 6 to 8 weeks. The topics for the discussions have been the scope requirements, the AAM, the complete ARM, the UoF structure, the AIM mapping, the conformance classes (CC) and the conformance requirements. On specific topics like kinematics, FEA, configuration/specification the relevant expertise has been involved: Ad-hoc exert groups have been established on these topics.

The activities are supported by the experts of the following companies:

Adam Opel AG, Germany	ITT Automotive Europe GmbH, Germany
Audi AG, Germany	Keiper Recaro, Germany
BMW AG, Germany	Mercedes-Benz AG, Germany
Carl Schenck AG, Germany	ProSTEP GmbH, Germany
Daimler Benz AG, Germany	QuantumSTEP, U.K.
debis Systemhaus GmbH, Germany	ProSTEP, Germany
Delphi Automotive Systems GmbH, Germany	Robert Bosch GmbH, Germany
DiK (TH Darmstadt), Germany	RPK (Uni Karlsruhe), Germany
Dr.Ing.h.c.F. Porsche AG	SAP AG, Germany
EDS GmbH, Germany	Scania, Sweden
EDS/UG, U.K. and USA	Siemens AG, Germany
Eigner+Partner, Germany	Volkswagen AG, Gernany
Fordwerke Köln, Germany	Volvo Data Corp., Sweden
FZ Karlsruhe, Germany	ZF Friedrichshafen AG, Germany

Table 2-5: Attendees on German AP214 expert meetings

2.2 First AP214 CD Ballot

The first AP214 CD ballot was based on the AP214 document with the official number ISO TC184 SC 4 N319. The ballot period terminated on January 15, 1996. Within this period experts of 7 countries (i.e. France, Germany, Japan, Sweden, Switzerland, United Kingdom, and United States) reviewed in detail the complete AP214 documentation and submitted a total number of 1475 issues. Table 2-3 gives a statistical overview on the issues of the first CD ballot. In the table the issues are assigned with regard to their contents to the following data classes of AP214:

- Product structure (including properties and external references)
- Geometry (including measured data and model structures)
- Presentation/Draughting
- Form features (including tolerances and surface conditions)
- FEA/Kinematics
- General (AP harmonization, CC, etc.)

A further classification was implied with regard to the proposed editorial or technical changes:

- editorial and

- technical, concerning the ARM, the mapping/interpretation, the AIM or conformance requirements.

Group/UoFs	total	editorial	technical	ARM techn.	Mapp. techn.	AIM techn.	Test techn.
1 Prod. Structure S1,3,5,6,7,8, PR,E	**513**	**145**	**368**	**179**	**174**	**12**	**3**
2 Geometry G1,2,3,4,5,6,7, MD1,S2	**148**	**45**	**103**	**49**	**40**	**7**	**7**
3 Pres. Draugh. P1,2,3 D1,2	**153**	**59**	**94**	**43**	**44**	**7**	**0**
4 Form Feat. FF1,2,3,4, T1,2,C1	**439**	**111**	**328**	**147**	**163**	**17**	**0**
5 FEA, Kinem. F1,2,3, K1	**113**	**36**	**77**	**66**	**8**	**0**	**3**
6 General CCs,AP-Harm., etc.	**109**	**65**	**44**	**14**	**12**	**5**	**12**
Total	**1475**	**461**	**1014**	**498**	**441**	**48**	**25**

Table 2-6: Statistics of issues on the first CD of AP214

Additional to the official ballot comments during the development of the second CD of AP214, several inofficial issues were raised. For the second CD version all official and inofficial issues were resolved, see /2/.

2.3 AP214 DIS Ballot

The DIS ballot was based on the AP214 document with the official number ISO TC184 SC4/WG3 N765. The ballot period terminated in November 1999. A total number of 382 editorially related issues were submitted. All issues were resolved (/11/ represents the related issue log).

3 Usage scenarios and usage tests

This clause of the Validation Report describes usage szenarios, i.e. descriptions of sequences of industry events using portions of the product data defined in the scope of AP214.

3.1 BoM Example

For detailed description see page 19, clause 5.3.2.2.

3.2 Machining Features for Press Die Machining

For detailed description see page 44, clause 5.3.3.2.

3.3 Process Plan for Equipment Design

For detailed description see page 76, clause 5.3.4.2.

3.4 Exchange of Sound Damping Part

For detailed description see page 108, clause 5.3.5.2.

3.5 Functional Description of 300 l Fuel tank for Truck

For detailed description see page 118, clause 5.3.6.2.

3.6 Substitution of Item version in a certain usage

For detailed description see page 124, clause 5.3.7.2.

3.7 Substitution of Item version in all its uses, on a certain date

For detailed description see page 126, clause 5.3.8.2.

3.8 Substitution of Item version as result of an activity

For detailed description see page 128, clause 5.3.9.2.

3.9 Form Features For Engine Component Design

For detailed description see page 131, clause 5.3.10.2.

3.10 Configuration control

For detailed description see page 150, clause 5.3.11.2.

3.11 Bill of Material of a VW Golf

For detailed description see page 154, clause 5.3.12.2.

3.12 Front Hood of VW Passat (Methods Development)

For detailed description see page 183, clause 5.3.13.2.

3.13 Shift Mechanism for 6-Speed Transmission

For detailed description see page 195, clause 5.3.14.2.

4 Scope and requirements evaluation

The formation for a STEP AP consists of an application's scope, functional requirements, and application activity model (AAM), which are defined and precisely documented (see /4/).

The validation of scope and requirements has been discussed on all organizational levels. There have been requirements exceeding the scope of the AP214 with regard to parametrics (for geometry, form features), kinematics (non-linear, dynamic multibody kinematics), specification/configuration (logistics, production, business processes), FEA (dynamic, non-linear FEA) and extentions to the life-cycle (e.g. CMM data, NC data). There has been a common understanding of all partners that the scope should remain restricted to the development process. Furthermore it was agreed not to define requirements that exceed the scope of the current Integrated Resources, i.e. requirements for parametrics, dynamic behaviour, etc. were rejected. The focus of AP214 on core data being exchanged and shared within the development process has been the guideline for reasoning. Due to the mismatch of the extended requirements of the automotive industry in the FEA area and the missing support of FEA within the technical restrictions in the Integrated Resources, it was decided at an international user workshop to drop FEA from the scope of AP214.

The validation of scope and requirements started in 1992 and was finalized in 1998. All issues raised were logged in the AP214 issue log (see /2/) and have been resolved.

5 ARM Validation

5.1 Review

The review of the ARM has been subject to several ISO-meetings (see Table 2-2), international automotive expert meetings (see Table 2-4) and technical discussions of the German AP214 development project.

The results, i.e. the raised issues of the reviews are documented in the AP214 issue logs for the first CD (see /7/) and for the second CD document (see/2/). With this ongoing expert review a coverage of the complete AP214 ARM could be achieved.

5.2 Harmonization with other related Application Protocols

The harmonization of AP214 with other APs overlapping was pursued and validated on several meetings on international level, especially at the ISO TC184 SC4 WG meetings. For some APs - e.g. AP203, AP209, AP212, AP224 - there were specific interoperability/harmonization workshops scheduled. The overlapping areas with respect to the UoFs of AP214 are shown in Table 5-1.

Data class	AP201	AP202	AP203	AP207	AP209	AP212	AP213	AP224	AP232 (TDP)
Product management data	S1	S1	S1, S3, S4, S5, S7	S1, S3, S5	S1, S4, S5, S7	S1, S3, S4, S5, S6, S7	S1, S3, S5	S1	S1, S3, S4, S5; S7
Geometric representations	G1, S2	G1, G2, G3, G4, G5, S2	G2, G3, G4, G5	G2, G3, G4, G5, G7	G2, G3, G4, G5, S2		G2, G3, G4, G5	G5	
Presentation and draughting	P1, P2, D1	P1, P2, D1, D2				P1, P2, D1	P1, P2, D1		
Form features				FF1				FF1, FF2	
Process plan				S8			S8		
Property, tolerances		T1	PR1	PR1, T1, T2	PR1	PR1	PR1, T1, T2	PR1, T1, T2	PR1
External references			E1			E1			E1

Table 5-1: Harmonization areas for AP214

5.3 Examples for ARM instantiation

5.3.1 Overview

The text for the validation of these examples is structured as follows:

- Abstract:
  This subclause includes organizational information about the owner of the example, the date when the example was issued, the referenced version of the AP214-document and a short description about the industrial background of the example.
- User description:
  This subclause consists of an informal description of the example using the terminology of the application experts. Figures are included in order to clarify and explain the terminology, the type of parts which are concerned and the processes which create or use product data describing the parts.
- Mapping to the AP214 ARM:
  This clause describes, how the relevant product data can be mapped to the ARM of AP214 to support the processes described by the user. The mapping is described essentially by the graphical representation of the instantiation of relevant extracts of the example. The method for the graphical representation is introduced in figure 4-2.
- Discussion:
  This clause includes a discussion of the mapping in order to evaluate the accordance of the AP214 ARM to industrial requirements and to derive issues against the ARM where necessary.

The figure below shows the two variants which are used within the examples for graphical representation of instanciated AP214 ARM structures:

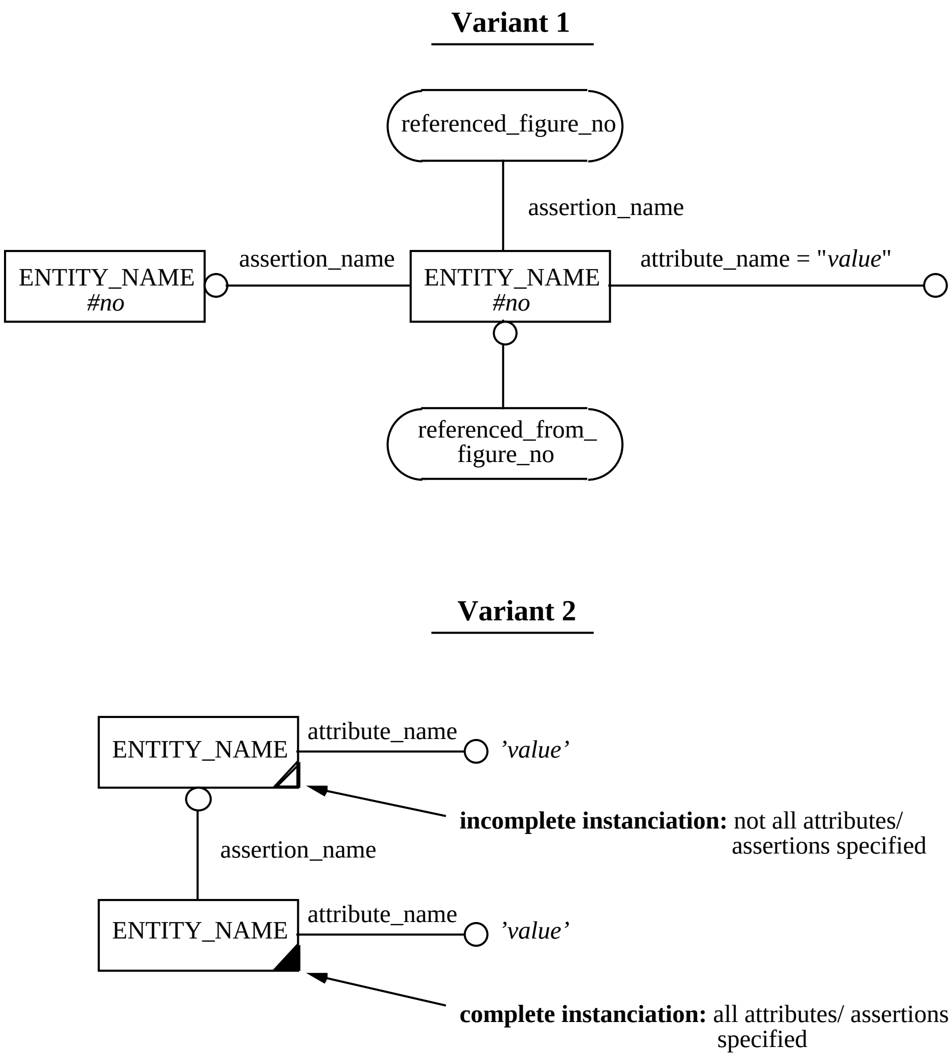

Figure 5.3.1-1: Method for the graphical representation of the instanciation

Up to now, thirteen examples comprising different stages of a products life cycle and containing a variety of product and process related data are available. With relevance to the numerical order, the available examples are:

1. BMW AG: BoM Example – Production BoM TAIS II
2. Honda: Machining Features for Press Die Machining
3. Honda: Process Plan for Equipment Design
4. Rieter: Exchange of Sound Damping Part
5. Scania: Functional Description of 300 l Fuel Tank for Truck
6. Scania: Substitution of Item_Version in a Certain Use
7. Scania: Substitution of Item_Version in all its Uses, on a Certain Date

8. Scania: Substitution of Item_Version, as Result of an Activity
9. Toyota/Honda: Form Features for Engine Component Design
10. Volvo: Configuration Control
11. VW: Bill of Material of a VW Golf
12. VW: Front Hood of VW Passat (Methods Development)
13. ZF: Shift Mechanism for 6-Speed Transmission

The examples have been chosen with the purpose of validation of all UoFs. The aspects of these examples as well as the covered UoFs are shown in the following tables:

AP214 UoFs	Example	1	2	3	4	5	6	7	8	9	10	11	12	13
S1	Product_management_data	X	X	X	X	X	X	X	X	X	X	X	X	X
S2	Element_structure	X												
S3	Item_definition_structure	X		X	X							X		X
S4	Effectivity	X						X				X		
S5	Work_management	X					X		X			X		
S6	Classification	X				X						X	X	
S7	Specification_control	X				X	X				X	X		
S8	Process_plan			X	X									
G1	Wireframe_model_2D													
G2	Wireframe_model_3D													
G3	Connected_surface_model				X									
G4	Faceted_B_rep_model													
G5	B_rep_model		X							X				
G6	Compound_model		X							X				
G7	CSG_model													
G8	Geometrically_bounded_surface_ model													
MD1	Measured_data													
PR1	Item_property	X		X										
P1	Geometric_presentation													
P2	Annotated_presentation				X									
P3	Shaded_presentation													
D1	Explicit_draughting													
D2	Associative_annotation				X									
K1	Kinematics													

AP214 UoFs	Example	1	2	3	4	5	6	7	8	9	10	11	12	13
FF1	User_defined_feature		**X**							**X**				
FF2	Included_feature		**X**							**X**				
FF3	Generative_featured_shape		**X**							**X**				
C1	Surface_condition		**X**											
T1	Dimension_tolerance		**X**											
T2	Geometric_tolerance		**X**											
E1	External_reference_mechanism												**X**	**X**

Table 5-2: UoFs covered by AP 214 validation examples

5.3.2 BMW AG: BoM Example – Production BoM TAIS II

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Created: September 1998

Reference document: ISO TC184/SC4/WG3 N756

Reworked/adapted to IS version (N931) by Christian Donges, ProSTEP (May 2000)

5.3.2.1 Abstract

The following example has been realised with specific BMW BoM data. Its special purpose is to describe a BMW BoM which can be exchanged with other automotive manufacturers. It contains an example of an assembly as well as some master data for a specific part.

5.3.2.2 User Description

The following section presents information to the mapping of BMW BoM product data to STEP/AP214 (ARM).

Note: CAPITAL LETTERS specify a STEP object (entity)

italic letters specify an attribute name of a STEP object

Product Hierarchy - PRODUCT_CLASS (Figure G 1)

The cars at BMW vehicles are classified in model lines. Within each model line there are four structure levels:

- Enterprise
- Engineering Series
- Engineering Project
- Model Type

In order to distinguish a BMW BoM from those of other companies the first level of PRODUCT_CLASS was defined. In the administrative systems the top level entry is the Engineering Series without any link to preceding and following project. The Engineering project is the top level entry to the bill of material. A Model Type represents a complete vehicle which can be built. The Model Type is the top entry for the structure of a BoM. For each Model Type, a set of base features is supplement by a set of options to define the full vehicle. Among the base features are e.g.:

Body style

Engine series and capacity

Base Territory

Feature Definition - SPECIFICATION (Figure 3, Figure 4)

Each Model Type has defined a specific set of basis features. Additionally a set of options is associated with it to generate a customer specific vehicle definition. Options are categorised as follows:

SA/LA/PA (special equipment)

SA - customer options (first letter S)

LA - territorial options (first letter L)

PA - packages (first letter P)

AFL (colour and trim)

A – trim

F - interior colour

L - exterior colour (paint)

Feature Availability - CLASS_SPECIFICATION_ASSOCIATION (Figure 3, Figure 4)

The application of a feature to a Model Type can be conditioned in the following ways:

- Not Applicable
- Optional
- Special customer request only
- No longer valid
- Planned for future introduction
- Standard

Option Conditions - SPECIFICATION_EXPRESSION (Figure 13)

The option applicability statements can be conditioned in the following manner:

- Option A can not be with Option B (or Option C or Option D or ...)
- If Option E is ordered then it must also take Option F (and Option G and ...)

Because there is no concept of Exclusive Feature Groups in the BMW BoM, many of the rules of the first type above are merely clarifying this position.

Additionally, there are logic tables to express all rules which can not be expressed in the relatively simple form above. Such a table is called a Condition Decision Table. It is however rare to have to use this mechanism at the Option-to-Model Type level, they are more usually found at the part conditioning level. (Not in this example)

Assembly Structure Definition - Assembly Objects (Figure 5 to Figure 11, Figure 13)

The Model Type is the top level entry to the Bill of Material. It is here modelled as **PRODUCT_CLASS** (see Figure 2). Whether a part is in the BoM is evaluated through a **SPECIFICATION** (Figure 5) or a **SPECIFICATION_EXPRESSION** (Figure 13).

The Bill of Material is structured into construction groups (Vehicle Part Groups). The construction groups are (subdivisions of) functional units such as body shell, frame, seats, brake, rear axle, etc. In a construction group there are collected all parts of all types of a type family. The parts of one Model Type are marked by the type identifier.

Each line in the BoM is modelled as a **QUANTIFIED_INSTANCE** in this example. The ID of such an instance is derived from the Modell Type, the construction group and the line number in the BoM. An assembly is modelled as an **ASSEMBY_DEFINITION**.

The assembly structures create a multi-level hierarchical BoM. Only top level part numbers are assigned SA/LA/PA option conditioning usage statements but parts at all levels can be conditioned by AFL conditions.

Assembly Variations - CONFIGURATION (Figure 13)

If a complex assembly structure is the same as another except for perhaps one part which is fitted as the result of an option, then only one assembly structure is specified. The standard part which is replaced in the second structure will appear in the BoM with a negative option statement. The additional part will also appear with a positive option conditioning statement. This technique avoids creating many large assembly structures for similar assemblies.

5.3.2.3 Mapping to the AP214 ARM

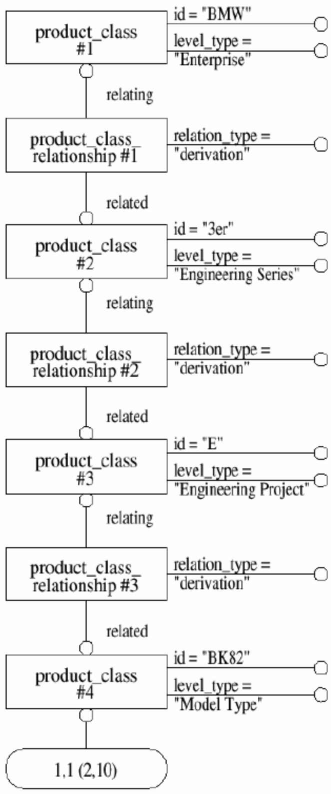


Figure 2: G 1 Product Hierarchy

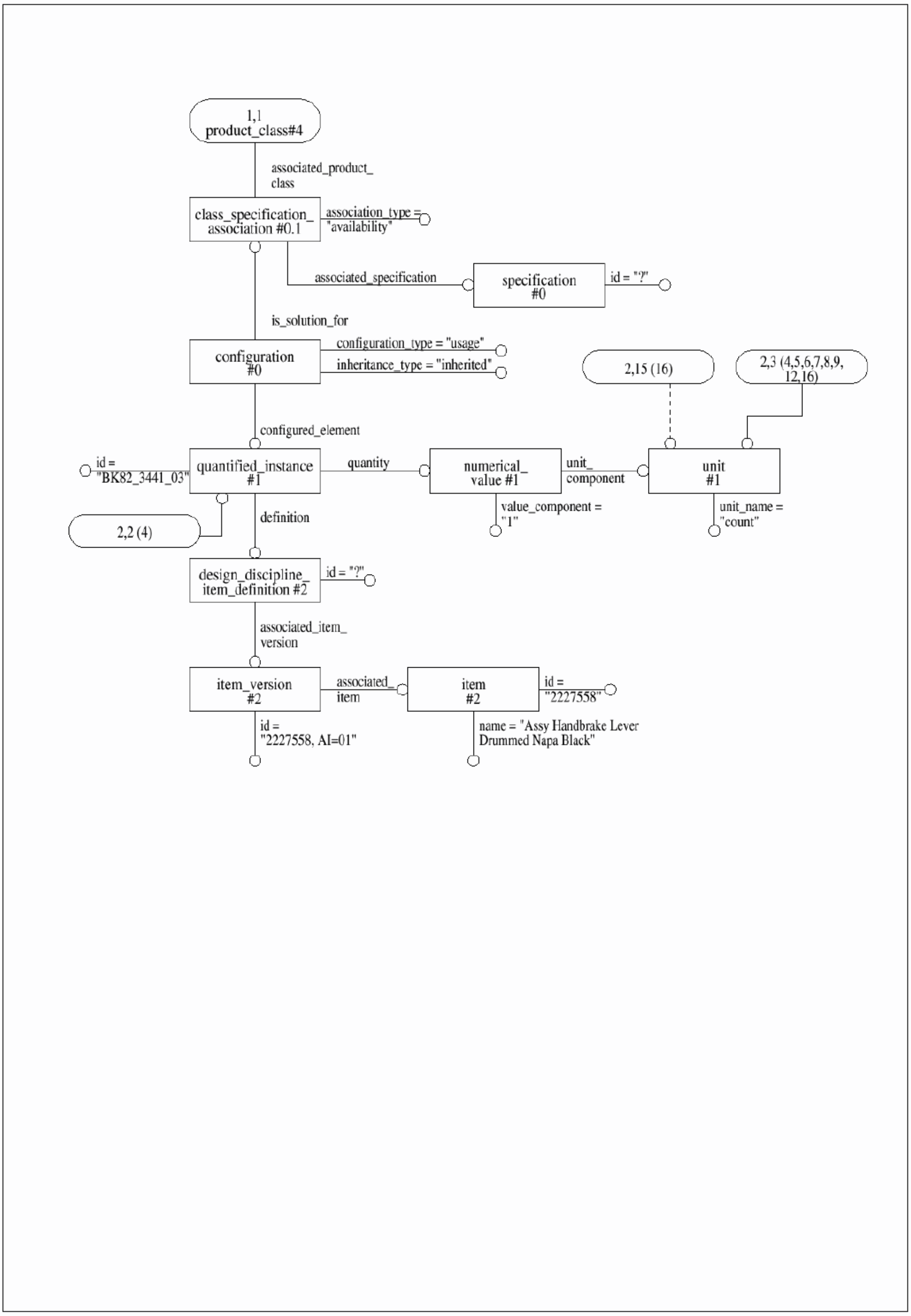
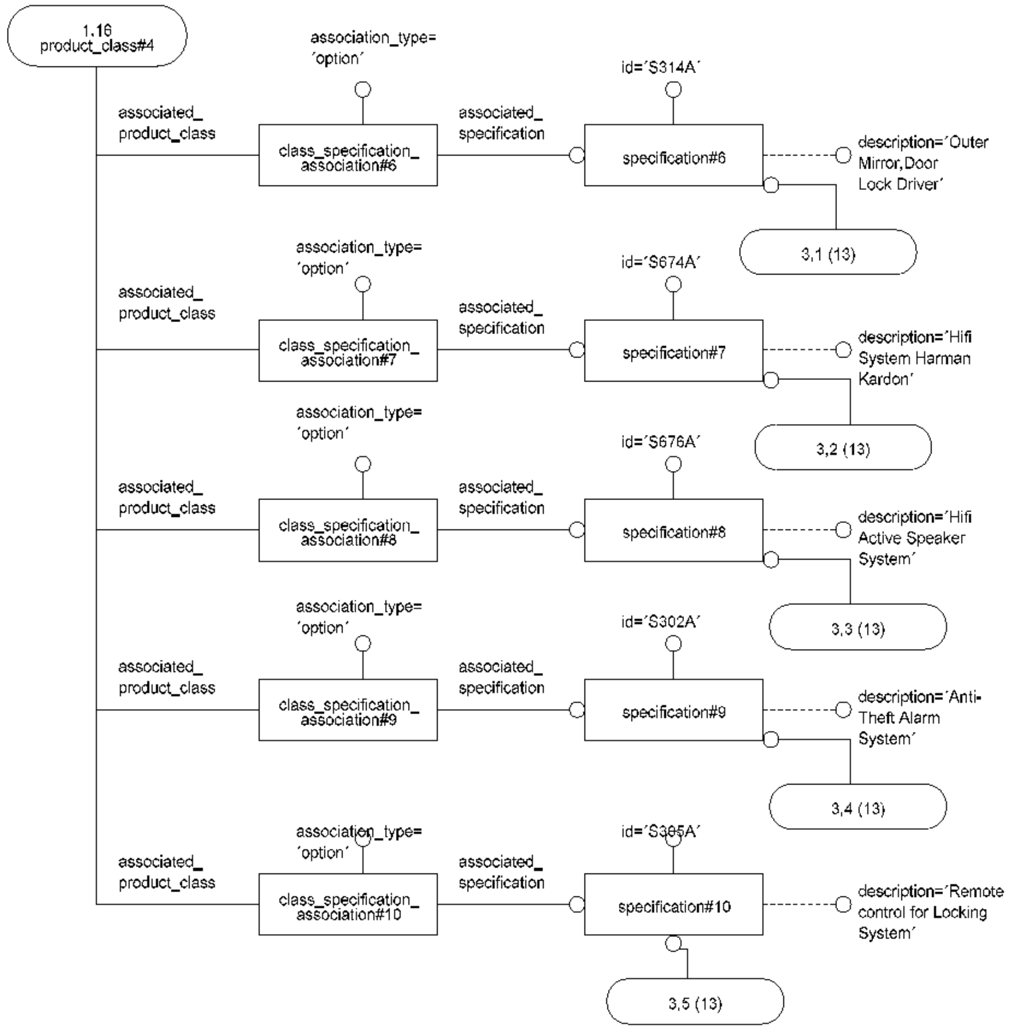


Figure 3: G 2 Specification

G 3 **Specification**



Note: An Attribute ? indicates that the data is not in the given example.
The related objects are needed for modelling reasons.

Figure 4: G 3 Specification

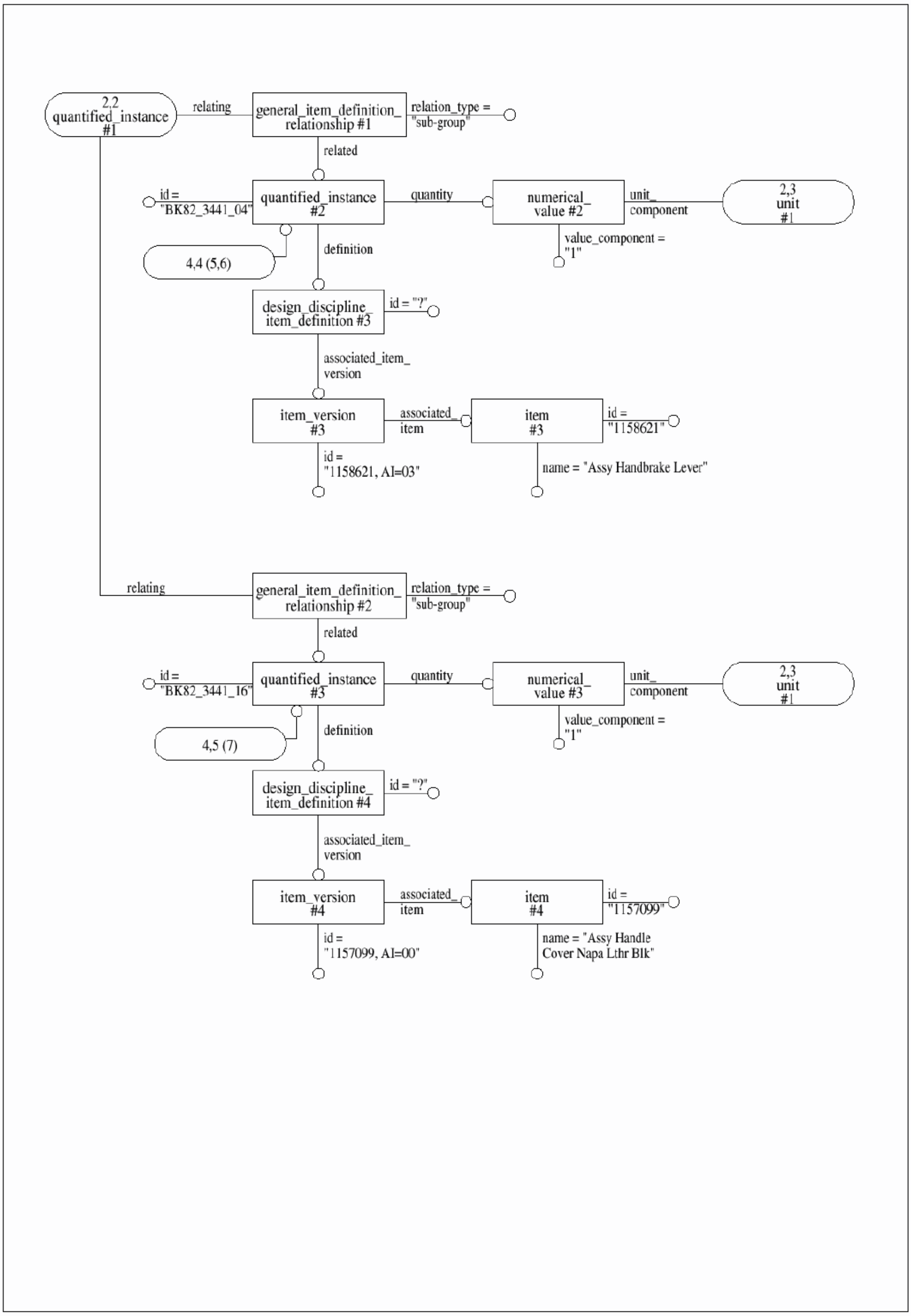


Figure 5: G 4 Structure Bill of Material

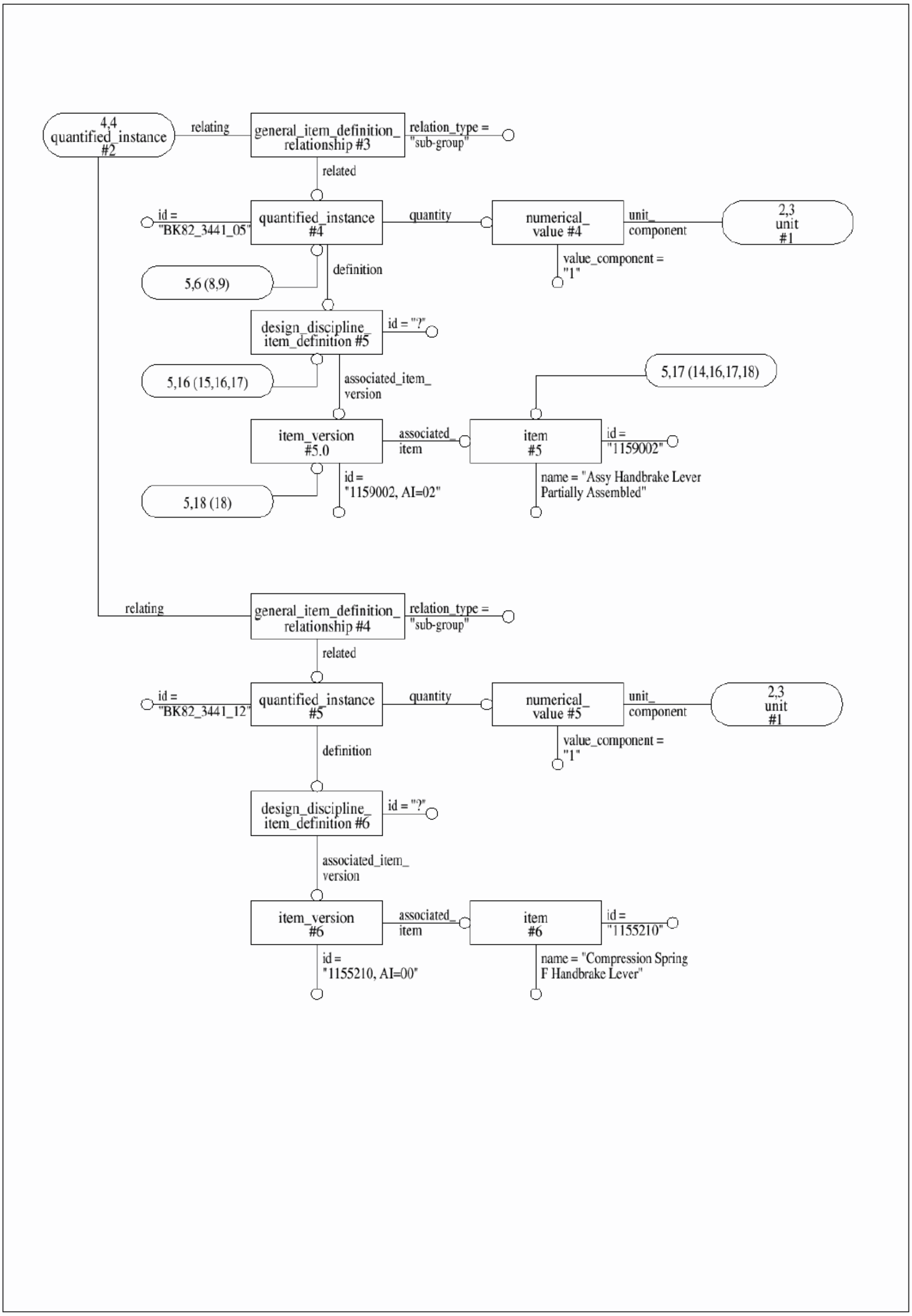


Figure 6. G 5 Structure Bill of Material

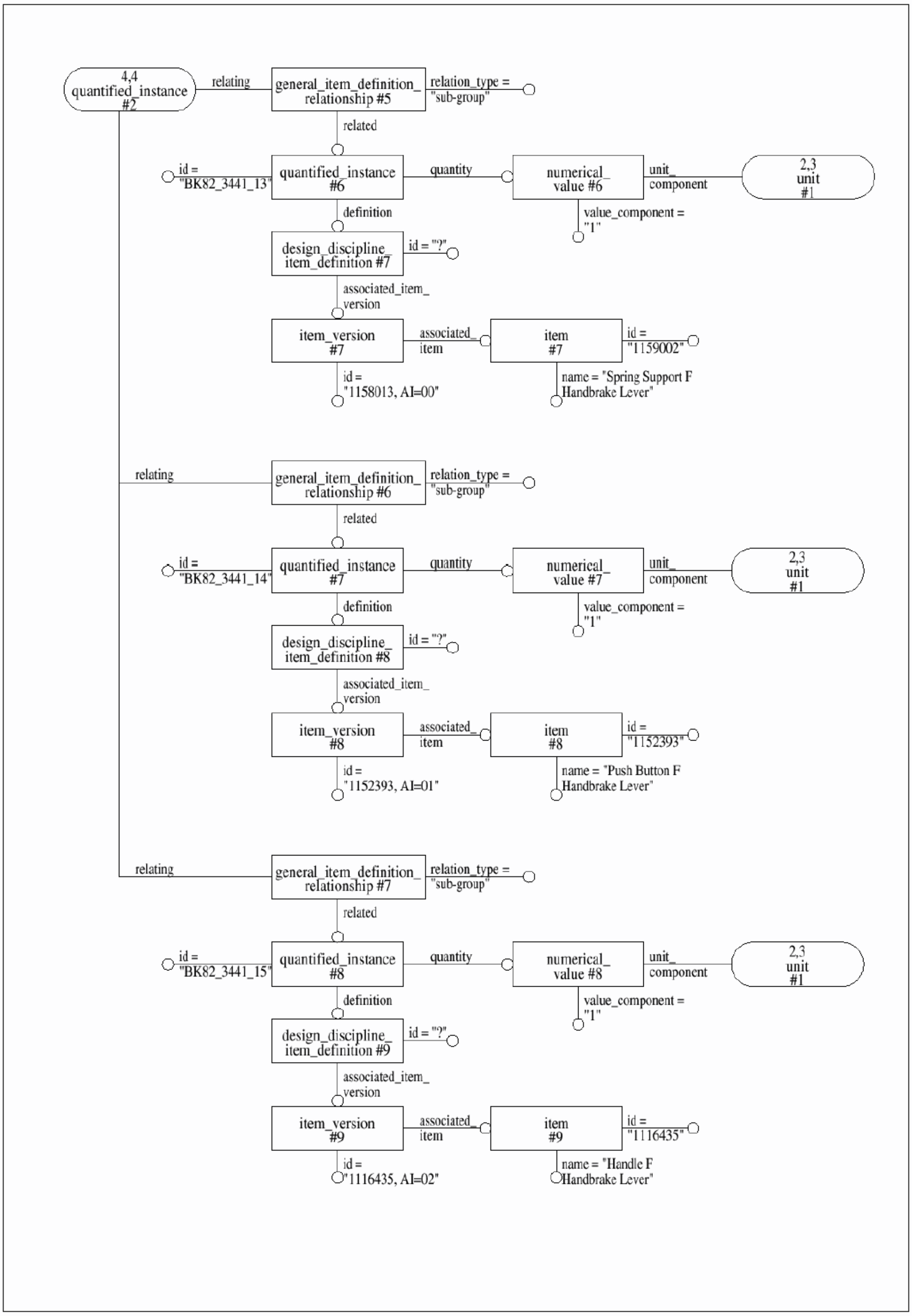


Figure 7: G 6 Structure Bill of Material

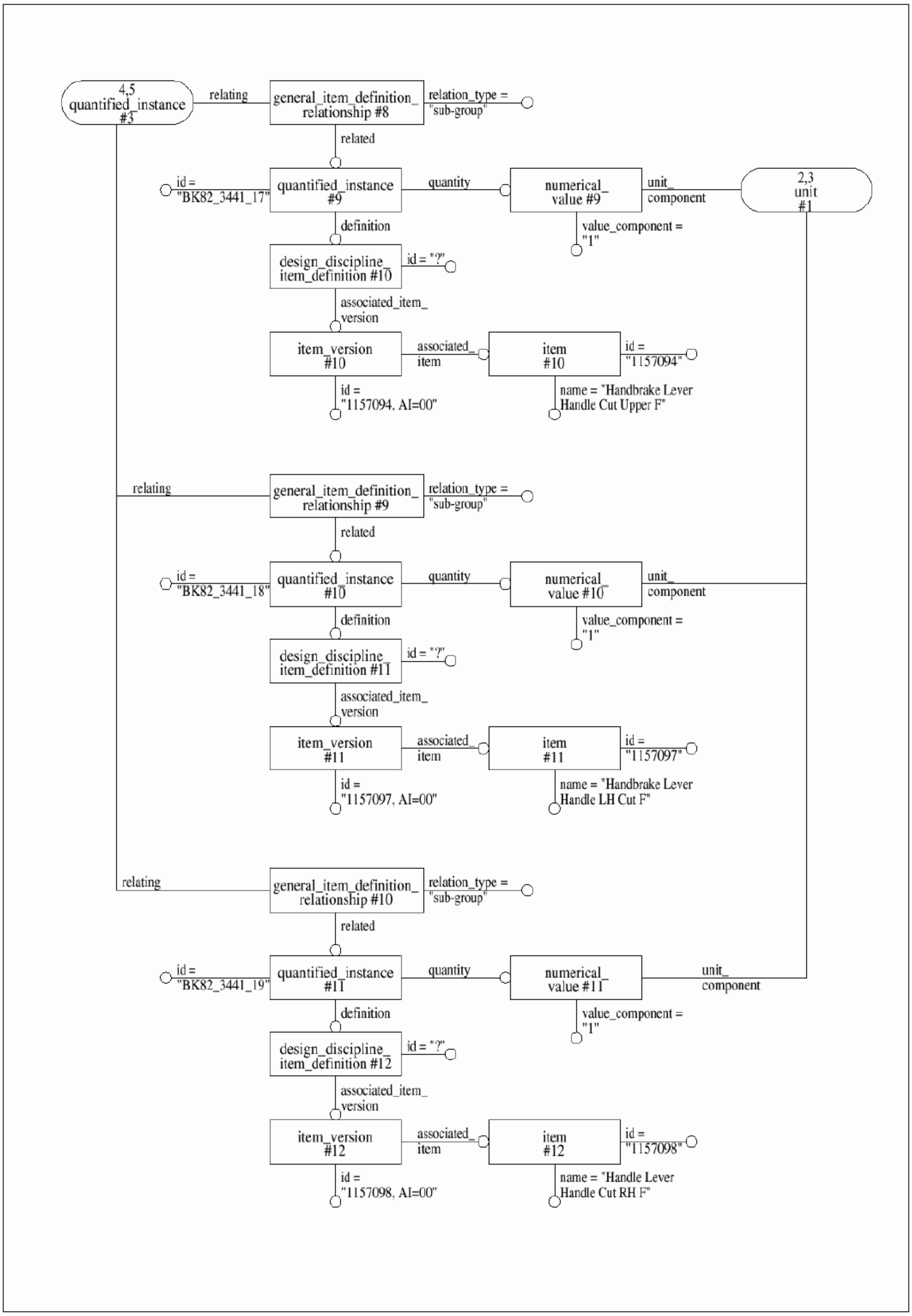


Figure 8: G 7 Structure Bill of Material

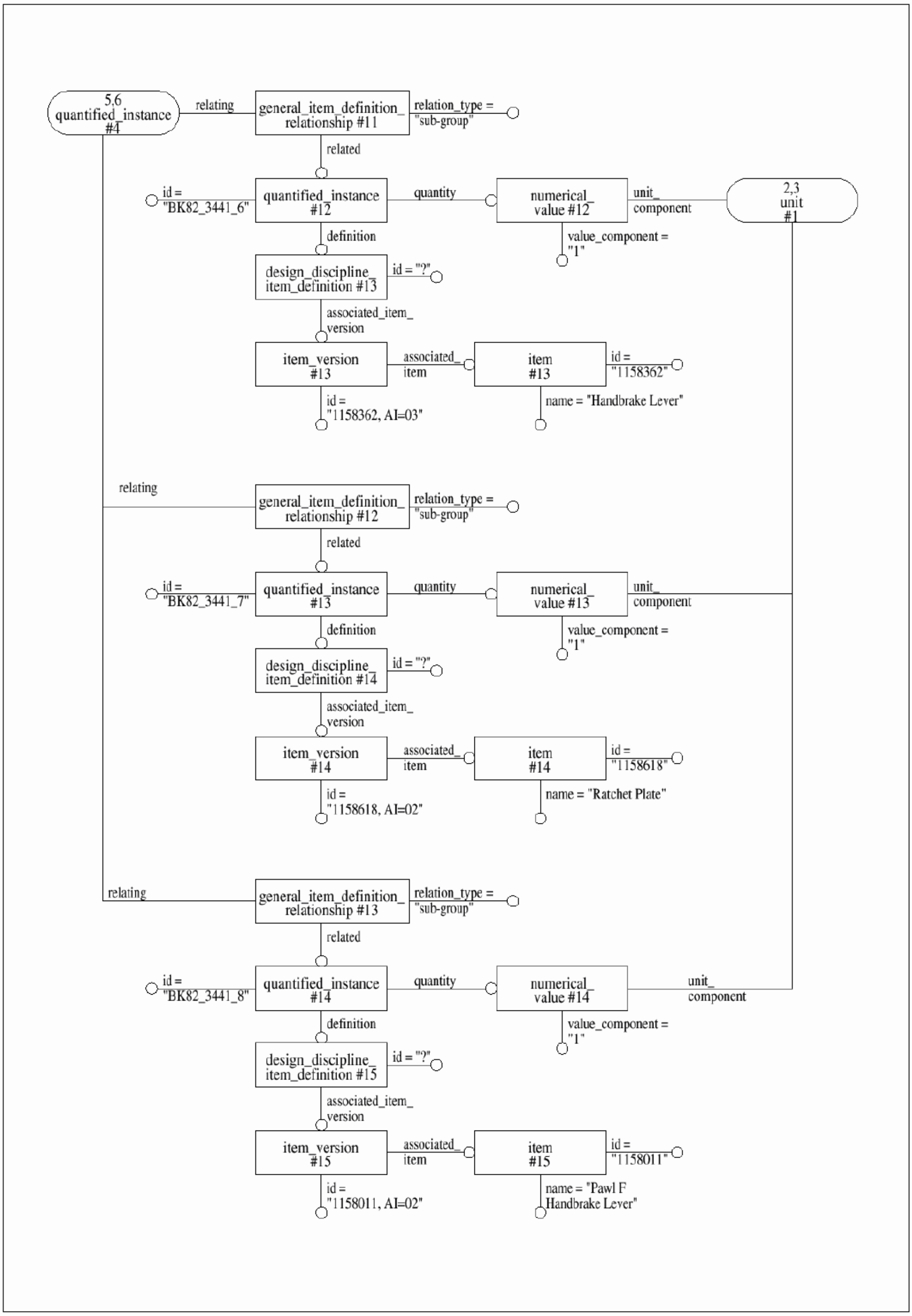


Figure 9. G 8 Structure Bill of Material

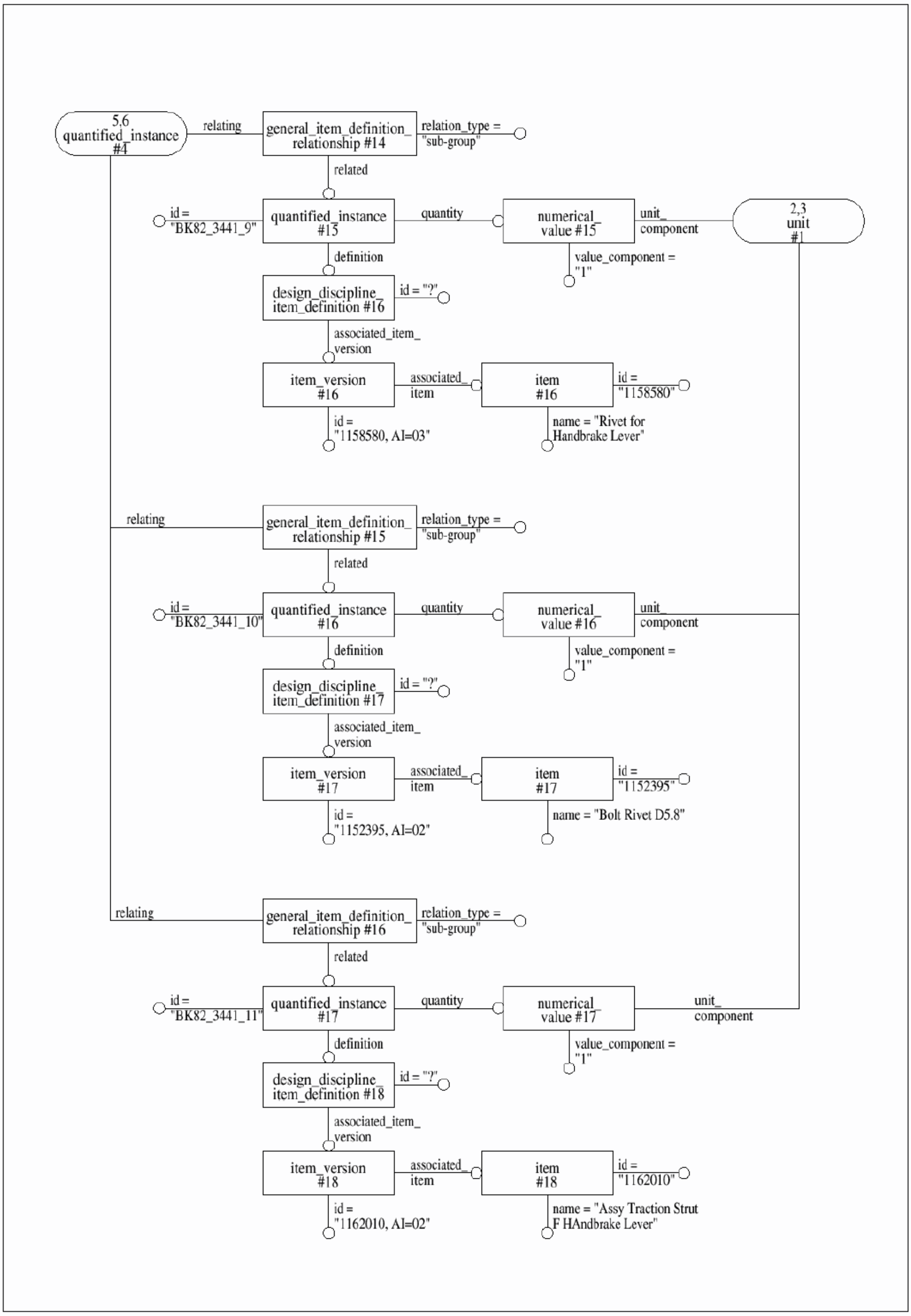


Figure 10. G 9 Structure Bill of Material

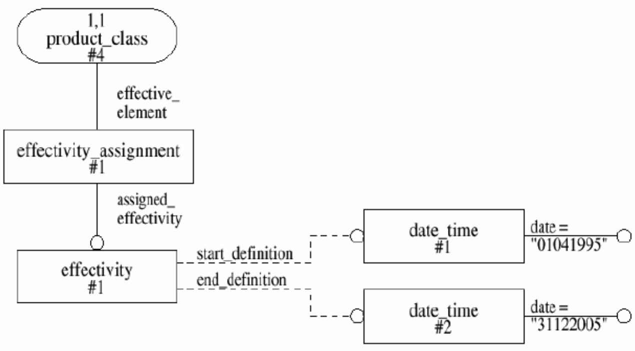


Figure 11. G 10 Structure Bill of Material

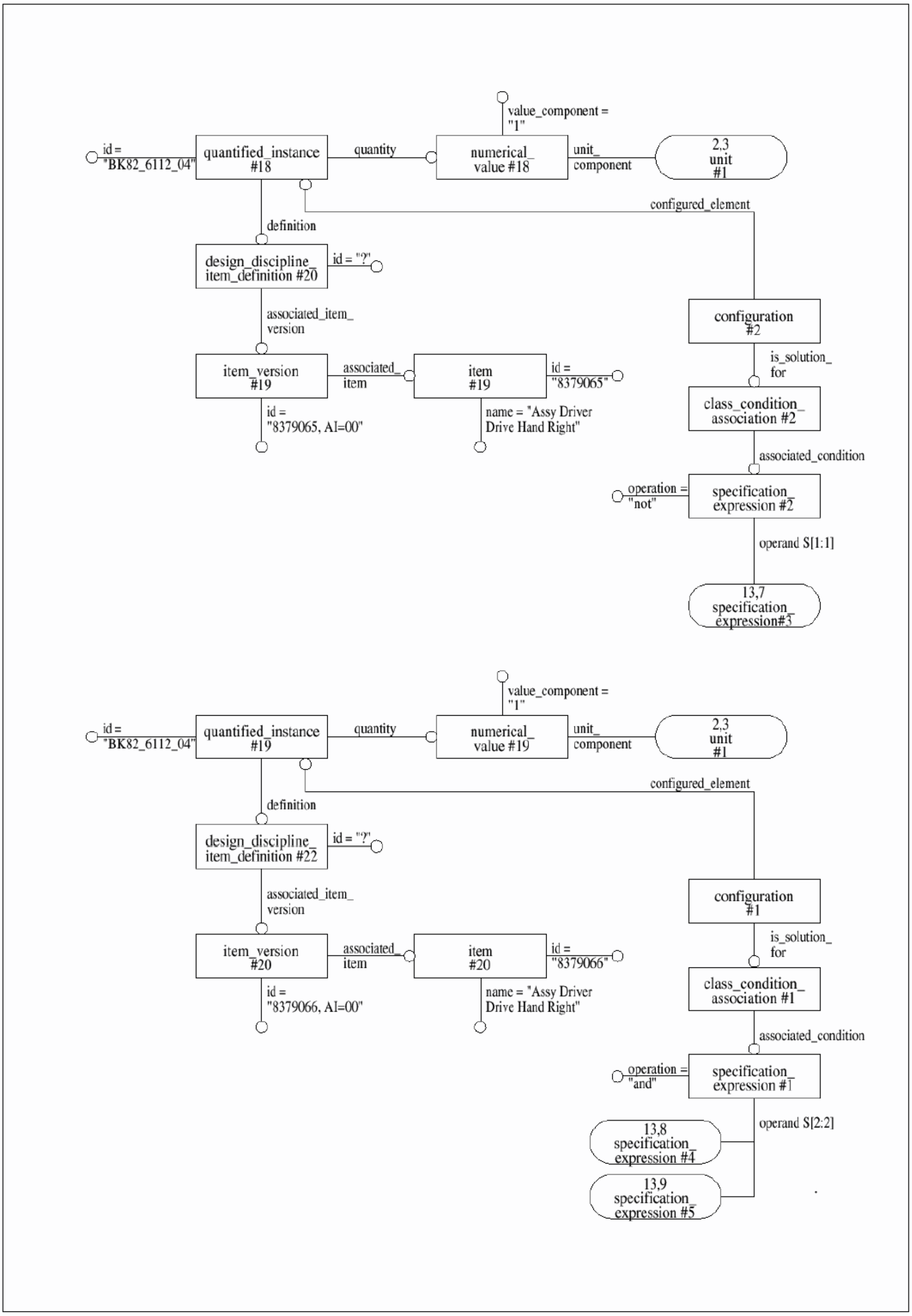


Figure 12. G 11 Effectivity Bill of Material

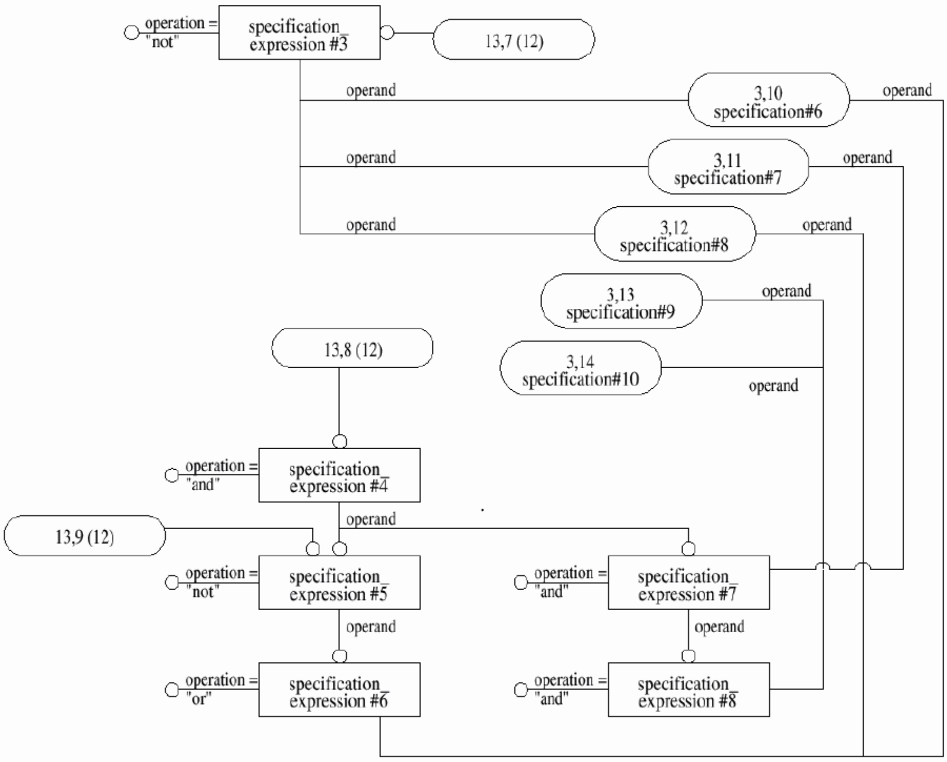


Figure 13. G 12 Structure Bill of Material, additional data

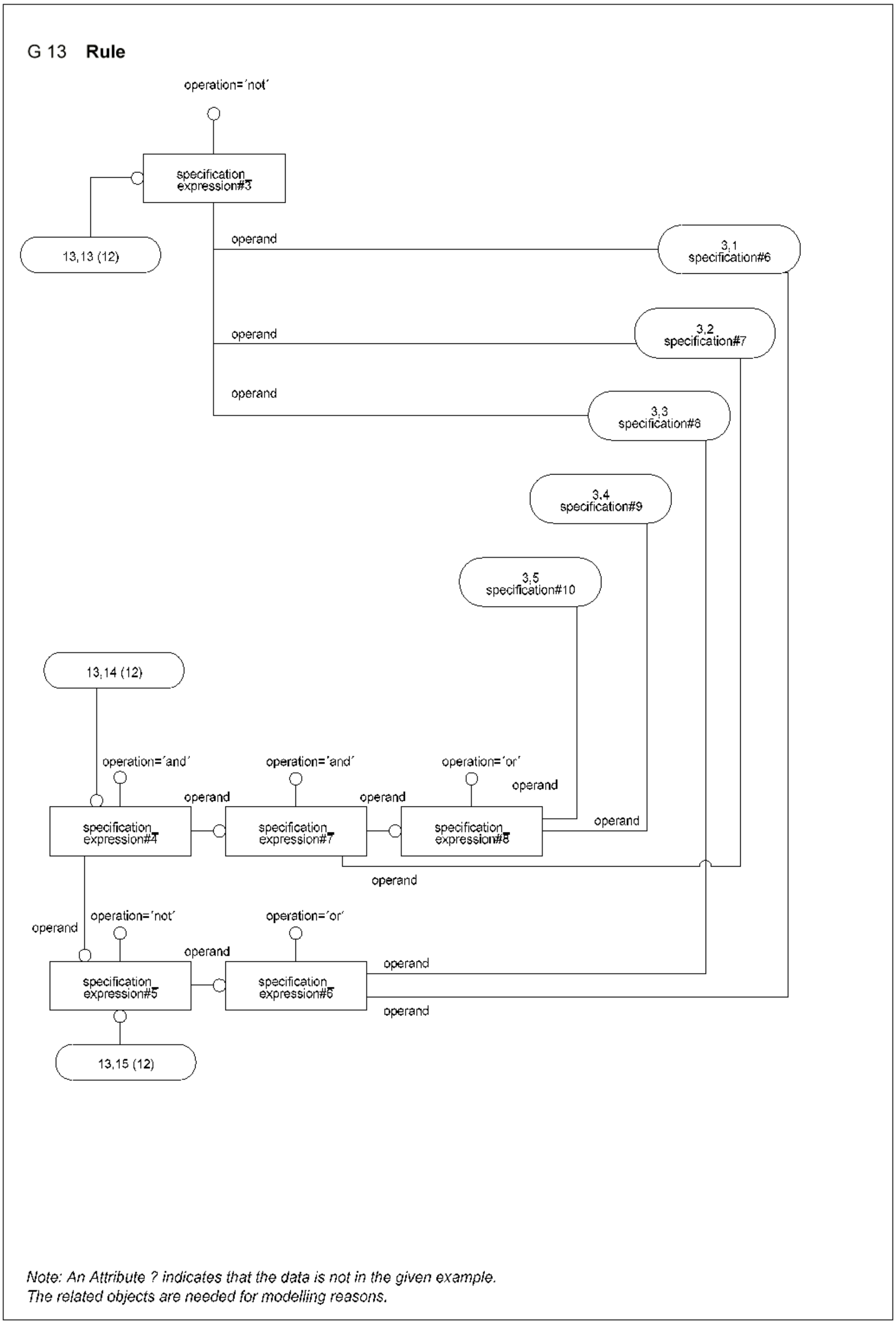


Figure 14. G 13 Rule

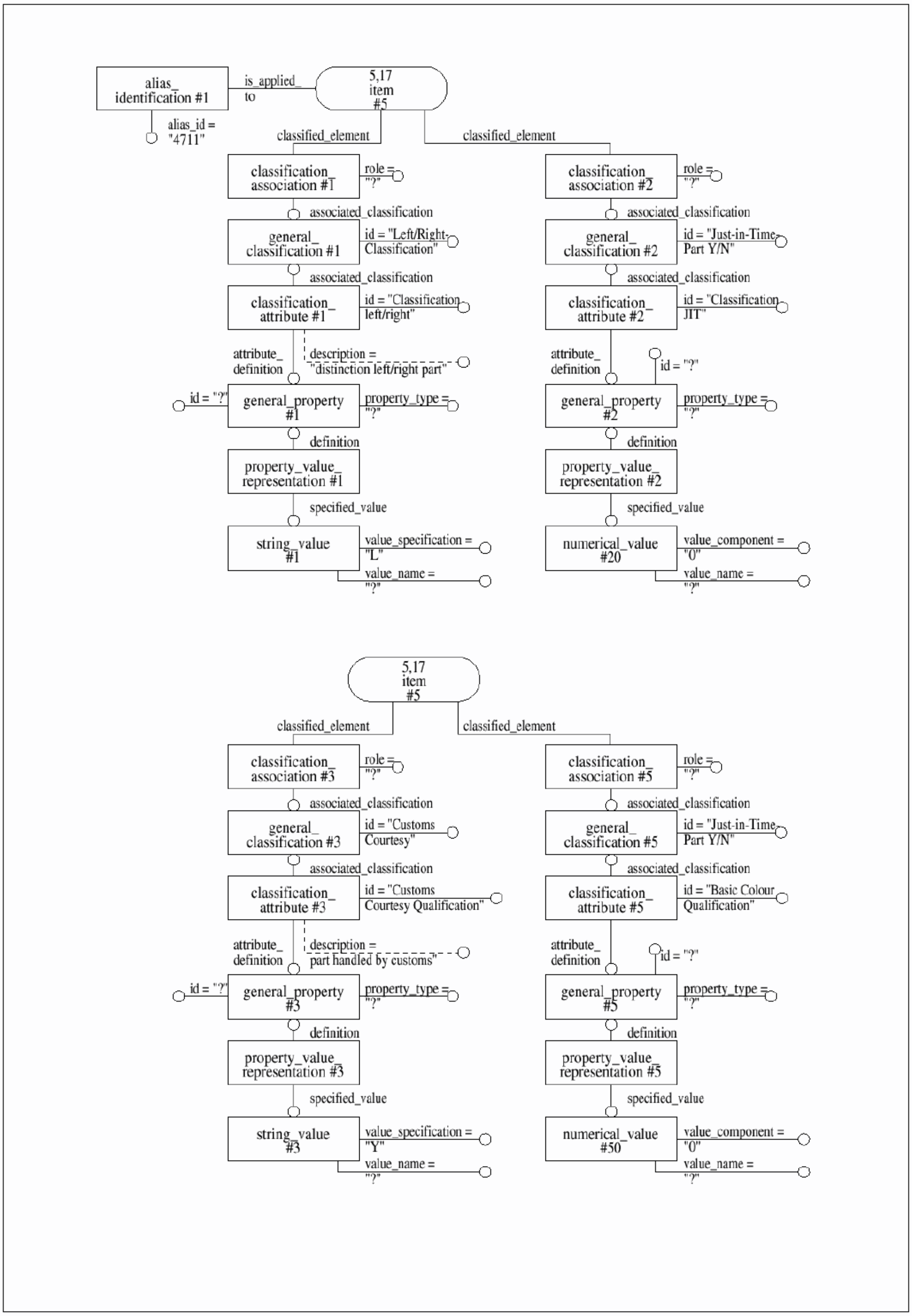


Figure 15. G 14 Master Data, specific part

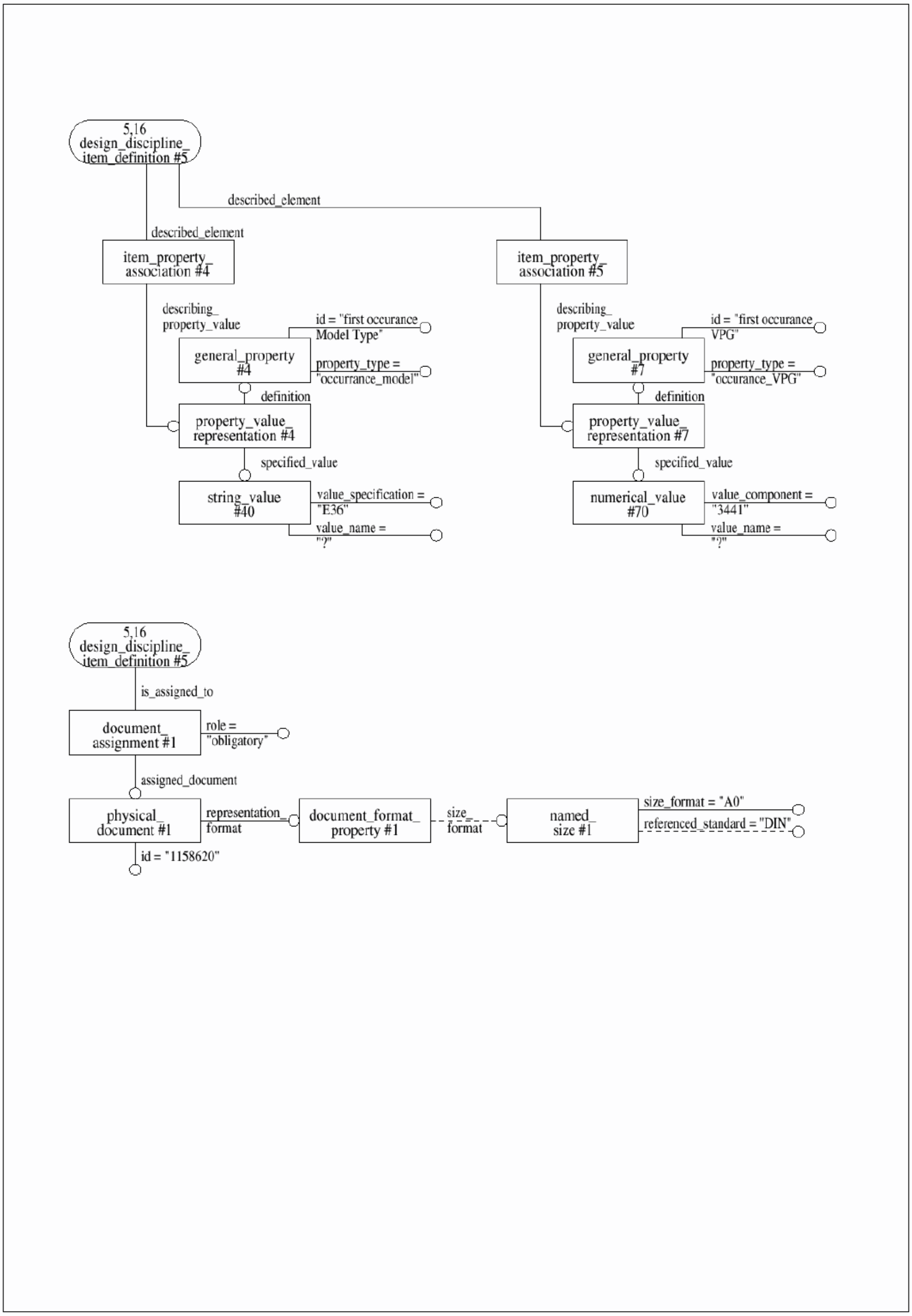


Figure 16. G 15 Master Data, specific part

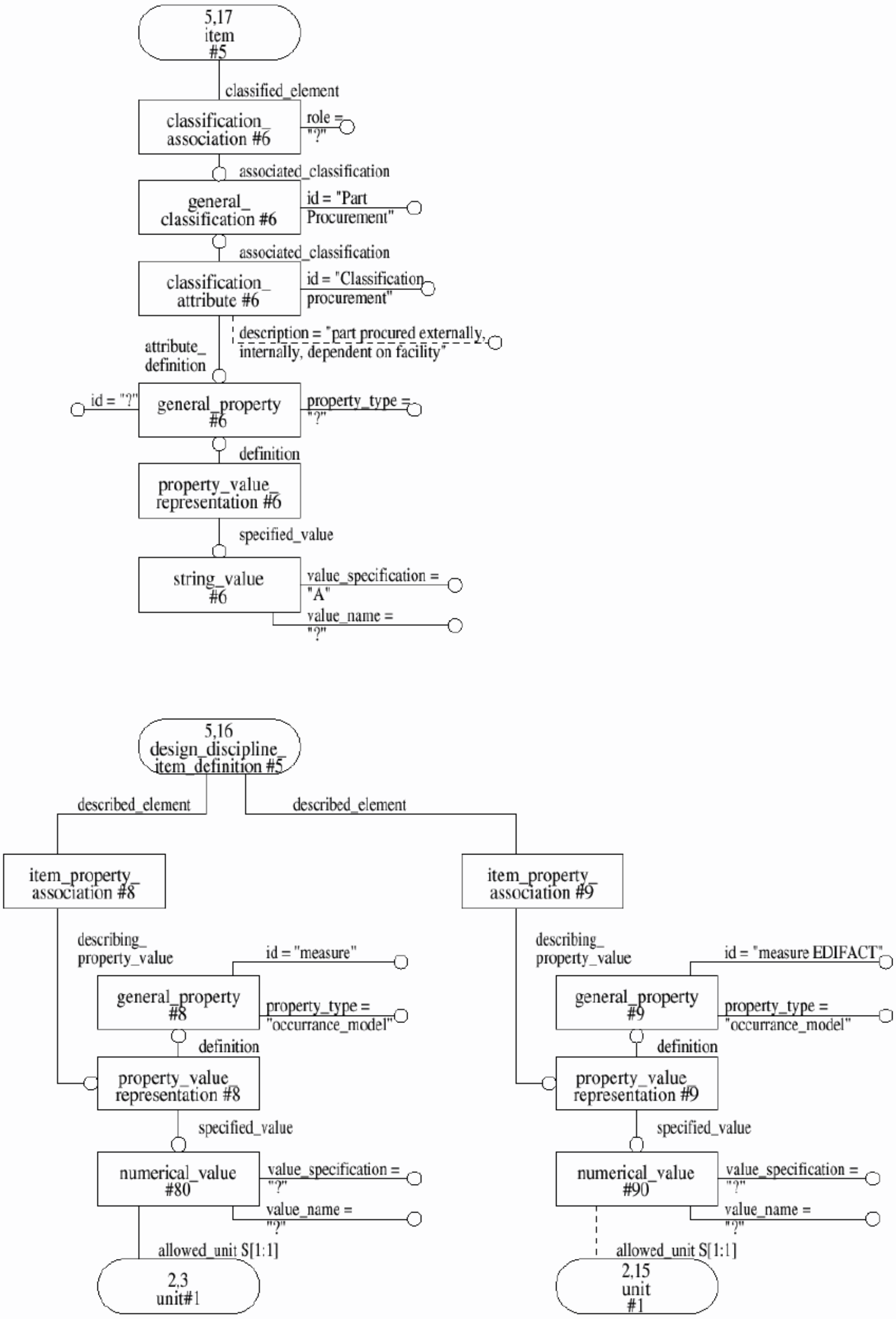


Figure 17. G 16 Master Data, specific part

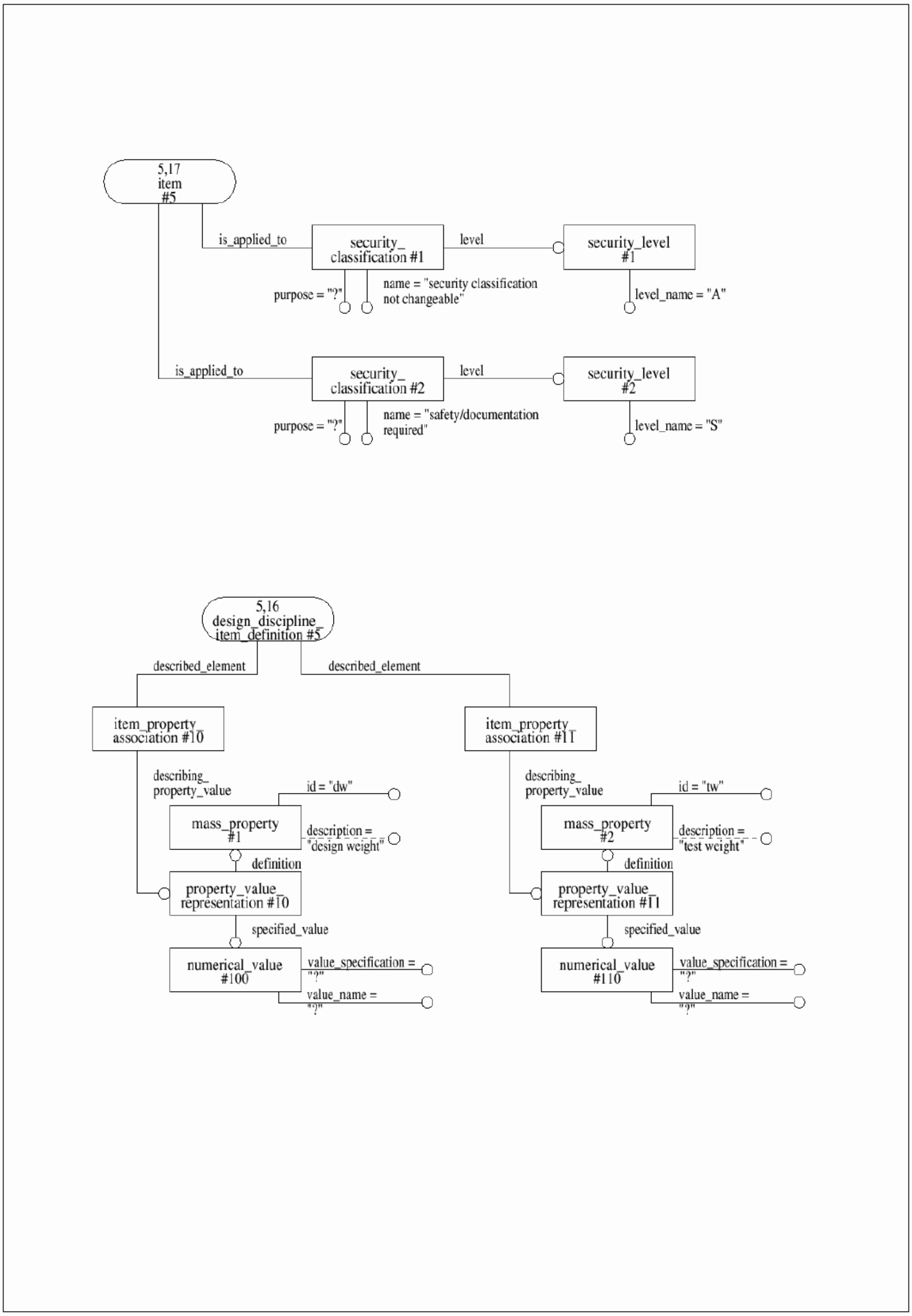


Figure 18. G 17 Master Data, specific part

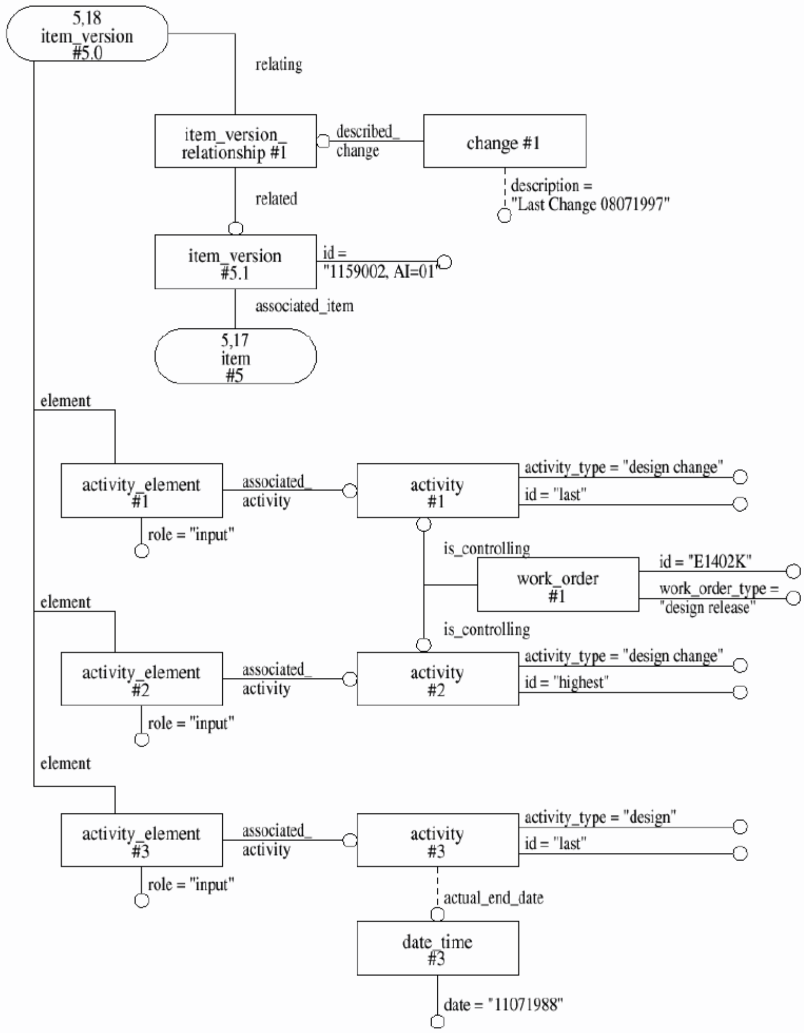


Figure 19. G 18 Master Data, specific part

5.3.2.4 Discussion

The following section discusses the relevant objects of STEP AP214 for this example.

Product Hierarchy - PRODUCT_CLASS (Figure G 1)

A **PRODUCT_CLASS** is the identification of a set of similar products to be offered to the market. Therefore the basic levels of product definition are mapped to an instance of PRODUCT_CLASS as well as the product range itself.

A **PRODUCT_CLASS_RELATIONSHIP** is a relationship between two PRODUCT_CLASS objects. The relationship of PRODUCT_CLASS objects defined by the PRODUCT_CLASS_RELATIONSHIP shall form an acyclic graph.

Feature Definition - SPECIFICATION (Figure 3, Figure 4)

A **SPECIFICATION** is a characteristic of a product. A SPECIFICATION discriminates one product from other constituents of the same PRODUCT_CLASS .

Features are mapped to SPECIFICATIONs.

Feature Availability - CLASS_SPECIFICATION_ASSOCIATION (Figure 3, Figure 4)

A **CLASS_SPECIFICATION_ASSOCIATION** is a relationship between a SPECIFICATION and a PRODUCT_CLASS . This SPECIFICATION serves as a potential characteristic of all products belonging to the PRODUCT_CLASS.

The *association_type* specifies the kind of availability of a particular SPECIFICATION in a PRODUCT_CLASS . Where applicable the following values shall be used:

- ’replaceable standard’
- ’non replaceable standard’
- ’availability’
- ’identification’
- ’option’

The following table shows the relationship between BMW and STEP values.

BMW	STEP
Not Applicable	
Optional	option OR availability
Special customer request only	option
No longer valid	option
Planned for introduction	option
Standard	non replaceable standard OR replaceable standard

Table 5-3: Mapping of BMW to STEP association_type(*s)*

The time component of time related options can be assigned by EFFECTIVITY, but it is semantically not the same.

Each feature (SPECIFICATION) is related to one (or more) product definition(s) (PRODUCT_CLASS) of the Model Type level.

Option Conditions - SPECIFICATION_EXPRESSION (Figure 13)

A **SPECIFICATION_INCLUSION** (not in this example) is the representation of the statement that the application of a SPECIFICATION or of a SPECIFICATION_EXPRESSION implies the inclusion of an additional SPECIFICATION or SPECIFICATION_EXPRESSION as described in the introduction to this Validation Report example.

A **SPECIFICATION_EXPRESSION** is a combination of SPECIFICATION objects formed by Boolean operations. Four kinds of operations are permitted:

’and’: all of the identified Specification objects shall be used;

’or’: a subset or all of the identified Specification objects shall be used;

’oneof’: exactly one of the identified Specification objects shall be used;

’not’: the identified Specification shall not be used.

A **CLASS_INCLUSION_ASSOCIATION** is the assignment of a SPECIFICATION_INCLUSION to a PRODUCT_CLASS. This assignment contains the information that a particular SPECIFICATION_INCLUSION applies for all products of that PRODUCT_CLASS. (not used in this example)

A **CLASS_CONDITION_ASSOCIATION** is a relationship between a SPECIFICATION_EXPRESSION and a PRODUCT_CLASS. This relationship contains the information that a particular SPECIFICATION_EXPRESSION is valid for all products of that PRODUCT_CLASS. (not used in this example)

Assembly Structure Definition - Assembly Objects (Figure 5 to Figure 11, Figure 13)

An **ITEM** is either a single object or a unit in a group of objects. It collects the information that is common to all versions of the object.

An **ITEM_VERSION** is the identification of a physically realisable object. It collects the information defining this object.

A **DESIGN_DISCIPLINE_ITEM_DEFINITION** is a view of an ITEM_VERSION relevant for the requirements of one or more life cycle stages and application domains. This view collects product data for a specific task, e.g. an assembly structure.

An **ASSEMBLY_DEFINITION** is a definition of an ITEM_VERSION that contains other subordinate ITEM_VERSION objects. An ASSEMBLY_DEFINITION is a type of DESIGN_DISCIPLINE_ ITEM_DEFINITION.

A **QUANTIFIED_INSTANCE** is the identification of the quantified occurrence of an object that is defined e.g. as a DESIGN_DISCIPLINE_ITEM_DEFINITION.

A **NEXT_HIGHER_ASSEMBLY** is a relationship where the attribute related specifies a constituent of an assembly and the attribute relating specifies the immediate parent assembly of the constituent. A constituent may be a single part or an assembly.

Assembly Variations - CONFIGURATION (Figure 13)

A **PRODUCT_COMPONENT** is an element in the product decomposition structure. A PRODUCT_COMPONENT is represented by a set of alternate ITEM_SOLUTION objects with common functional requirements. The top level PRODUCT_COMPONENT of the decomposition tree shall be associated to a PRODUCT_CLASS as root entry. The corresponding decomposition structure is identical for all variations of all products of that PRODUCT_CLASS.

A **CONFIGURATION** is the association of a SPECIFICATION_EXPRESSION or a SPECIFICATION with an ITEM_SOLUTION in the context of a certain PRODUCT_CLASS. The association may be limited by time, by serial number or by lot size. Each CONFIGURATION may be therefore one of the following: a SERIAL_CONFIGURATION, a LOT_CONFIGURATION, or a DATED_CONFIGURATION. At BMW the DATED_CONFIGURATION is by far the most prominent.

5.3.3 HONDA: Machining Features for Press Die Machining

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Created: September 1, 1998

Reference document: ISO TC184/SC4/WG3 N756

5.3.3.1 Abstract

We are studying whether it is possible to make a major contribution to die machining rationalization by transferring the die design information from the die design process to the die manufacturing process using the press die that is used to form the side outer panel, which is an automobile body structural component, as a case study.

To automatically calculate the NC data for die machining the design information expressed as geometrical representation, form feature, surface finish, and tolerance is generally used, but we are studying exactly what information is required and if this information can be expressed without inconsistency using AP214's ARM.

Die machining is divided into arbitrary surface machining, which covers arbitrary surfaces corresponding to the machining of product shape, excess shape, and the die face; and plane_and_hole machining, which covers the machining of flat surfaces, holes, taps, pockets, and slots; but for this project we are studying only plane_and_hole machining.

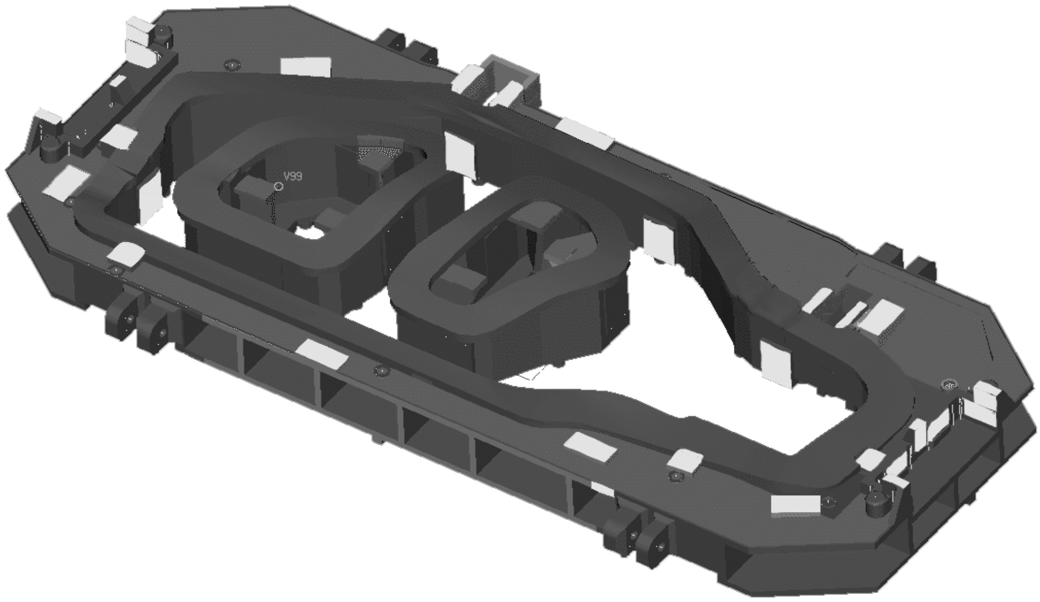

Figure 5-1 Press die of draw process for the side outer panel

5.3.3.2 User Description

5.3.3.2.1 Equipment Development Expectations for Form Features

Because information, such as form feature, surface finish, and tolerance, can be clearly expressed in the intent of the design, this information is expected to play an important role in rationalizing follow-up processes.

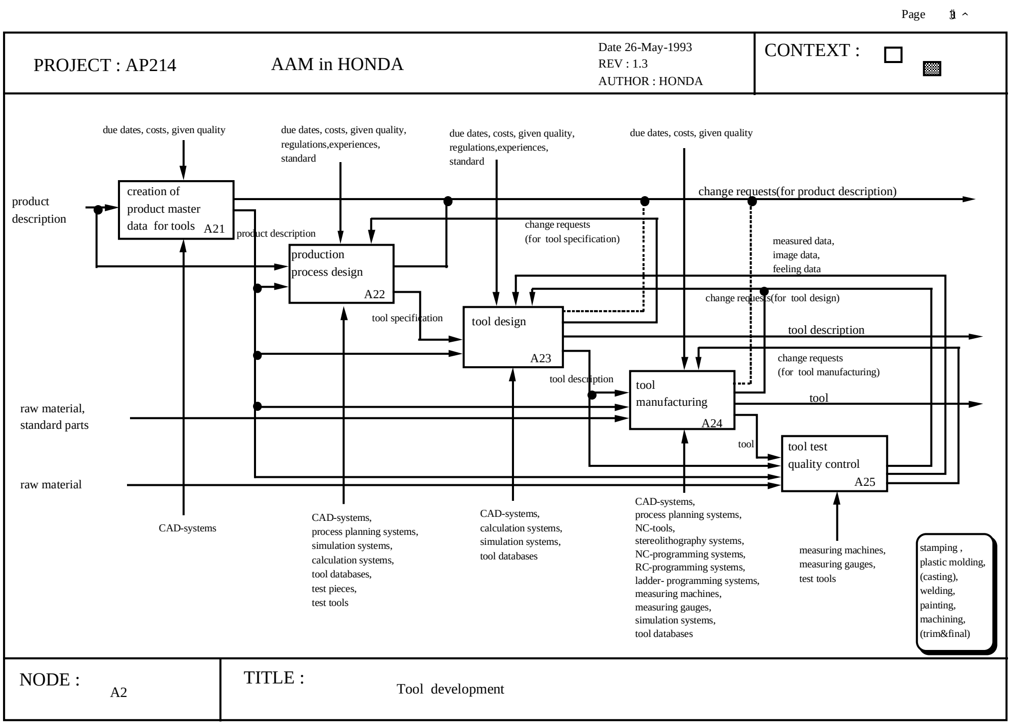

Figure 5-2 AAM of Tool development (A2)

The main effects that this information is expected to have on production equipment development are as follows.

- Rationalization of the production process design (A22 in Figure 5-2) process
  - Process design of engine component machining
  - Process design of body welding
- Rationalization of the tool design (A23 in Figure 5-2) process
  - Detailed design of special machining equipment for engine components
  - Detailed design of welding jigs
- Rationalization of the NC-programming (A241 in Figure 5-3) process
  - NC calculations for press die machining
  - NC calculations for plastics mold machining
  - NC calculations for casting mold machining
  - NC calculations for forging die machining
- Rationalization of the NC-programming (A242 in Figure 5-3) process
  - NC calculations for welding robot control in mass-production line

- NC calculations for engine machining equipment control in mass-production line

- Rationalization of the manufacturing of tools (A243) process

  - Inspections for die quality

  - Inspections for welding jig quality

- Rationalization of tool test and quality control (A25)

  - Measurement of formed panels

  - Measurement of machined engine components

In this way reason significant results are expected in many areas and processes related to production equipment development.

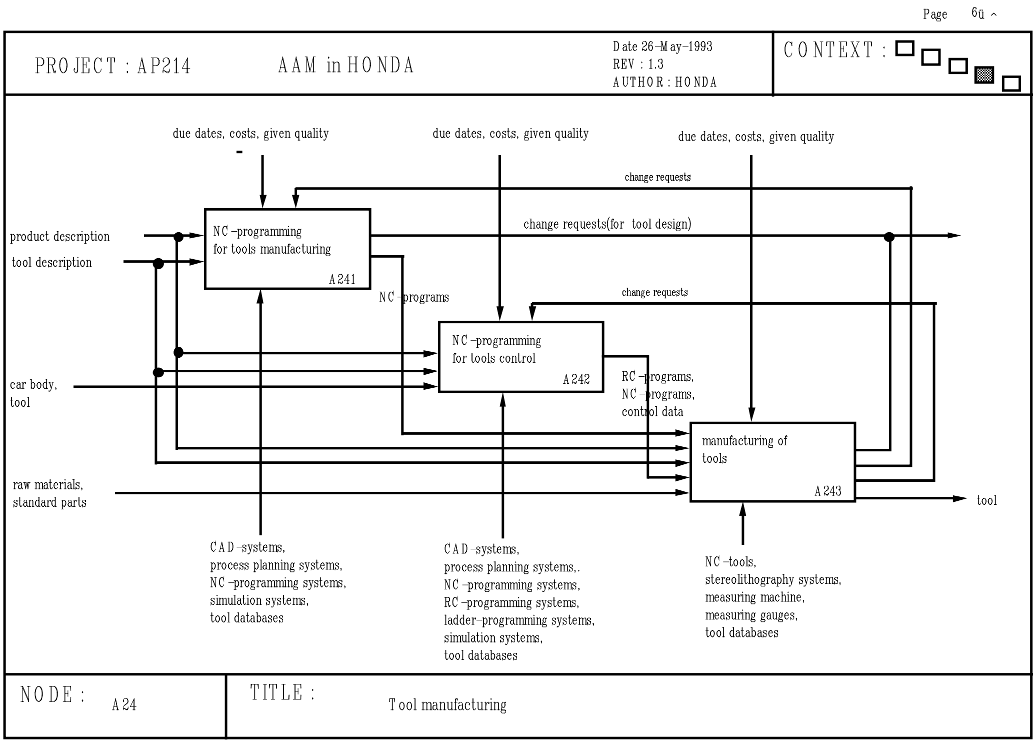

Figure 5-3 AAM of Tool manufacturing (A24)

5.3.3.2.2 Rationalization of NC Calculation for Press Die Machining

Herein we have studied the rationalization of NC calculation for press die machining. We chose this subject because it is important in automobile development for the following reasons.

- Panel quality, which impacts body quality, depends on the quality of the press die, and this quality is thought to be especially important in the automation of press die machining.
- To shorten the automobile development lead time, the development lead time of large dies, which have a long development lead time, must be shortened, and automation of die manufacturing has been avidly sought to accomplish this.
- Many press dies are required for each automobile development, and the press dies are unique to each model, so a general rationalization method is being sought.

Figure 5-4 Press die of bend process for the side outer panel

We decided to study press dies, which form the main framework of the automobile body. (Refer to Figure 5-4. Among many press dies chose the side outer panel because it is the largest and the most complex shape of all the automobile panels, so it requires the most difficult forming technology and the die to form it requires the longest development time.

The eventual goal of press die development rationalization is to be able to automatically calculate NC data after the die design is finished, and to make it possible to complete unmanned NC machining and no hand finishing.

To automatically calculate the NC data for die machining it is said that form feature, surface finish, and tolerance information is required in addition to geometrical representation, but we must study this in detail and see if this information can be expressed without contradiction in the AP214's ARM.

Die machining is divided into arbitrary surface machining, which covers arbitrary surfaces, and plane_and_hole machining, which covers the machining of flat surfaces, holes, taps, pockets, and slots. Here we will discuss the data required for surface hole machining NC calculations.

5.3.3.2.3 Input and Output Data of the NC-programming (A241) Process

The input data consists of the product description of the side outer panel, and the tool description of the side outer panel press dies (blank process die, draw process die, trim process die, first bend process die, second bend process die), and the UoFs that expresse these are shown in Figure 5-5.

The output data consists of the tool manufacturing process plan, which shows a die manufacturing process, and the NC-programs, which are run during process operation.

UoF		input	output	description
S1	product_management_data	O	O	
S2	element_structure	O	O	
S3	item_definition_structure			
S4	effectivity			
S5	work_management			
S6	classification			
S7	specification_control			
S8	process_plan		O	
G1	wireframe_model_2D			
G2	wireframe_model_3D	O	O	
G3	connected_surface_model	O	O	
G4	faceted_b_rep_model			
G5	b_rep_model			
G6	compound_b_rep_model	O	O	
G7	csg_model	O	O	
G8	geo_bounded_surface_model			
MD1	measured_data			
PR1	item_property	O	O	
P1	geometric_presentation			
P2	annotated_presentation			
P3	shaded_presentation			
D1	explicit_draughting		O	
D2	associative_draughting		O	
K1	kinematics			
FF1	user_defined_feature	O	O	
FF2	included_feature	O	O	
FF3	generative_featured_shape	O	O	
C1	surface_conditions	O		
T1	dimension_tolerances	O		
T2	geometric_tolerances	O		
E1	external_reference_mechan.	O	O	

Figure 5-5 UoF of Input/Output

Process level	Process ID.	Process name		Process type	Machining direction	Separate conditions	Continue conditions	End conditions	End conditions	End conditions
1	L-20101000-M	**FMC**	Y	FMC		2				
2	L-20101001-M	FMC end		FMC						
1	L-20102000-M	**Material**	Y	Material		2		L-20101000-M		
2	L-20102001-M	Material end		Material						
1	L-20103000-M	Primary processing	Y	Machining		2		L-20102000-M		
2	L-20103001-M	Die alignment		Die change						
2	L-20103002-M	Waste seat		Machining	Upper					
2	L-20103003-M	Reference surface--rough <reverse>		Machining	Lower					
2	L-20103004-M	Reference surface--finished		Machining	Lower					
2	L-20103005-M	Tightening surface <reverse>		Machining	Upper					
2	L-20103006-M	Key groove reverse reference		Machining	Lower					
1	L-20104000-M	**Primary surface ho**	N	Machining	Upper	2		L-20103000-M	L-20102000-M	
2	L-20104001-M	Die alignment		Die change	Upper					
2	L-20104002-M	Reference hole		Machining	Upper					
2	L-20104003-M	Distance seat		Machining	Upper					
2	L-20104004-M	Guide upper surface		Machining	Upper					
2	L-20104005-M	Cut line profile--rough		Machining	Upper					
2	L-20104006-M	Scrape cutter seat		Machining	Upper					
2	L-20104007-M	Insert set surface		Machining	Upper					
2	L-20104008-M	Cam unit set surface		Machining	Upper					
2	L-20104009-M	Lift up cycle set seat		Machining	Upper					
2	L-20104010-M	Guide surface--rough		Machining	Upper					
2	L-20104011-M	Guide hole--rough		Machining	Upper					
2	L-20104012-M	Scrape cutter set hole		Machining	Upper					
2	L-20104013-M	Insert set hole		Machining	Upper					
2	L-20104014-M	Cam unit set hole		Machining	Upper					
2	L-20104015-M	Lift up cycle set hole		Machining	Upper					
2	L-20104016-M	Remaining hole		Machining	Upper					
1	L-20105000-M	**Primary side**	N	Machining	Side	2		L-20104000-M	L-20103000-M	
2	L-20105001-M	Die alignment		Die change	Side					
2	L-20105002-M	Lift up cycle set seat		Machining	Side					
2	L-20105003-M	Lift up cycle set hole		Machining	Side					
2	L-20105004-M	Tightening groove		Machining	Side					
2	L-20105005-M	Location hole		Machining	Side					
2	L-20105006-M	Guide plate set hole		Machining	Side					
2	L-20105007-M	Scrap shoot set seat		Machining	Side					
2	L-20105008-M	Scrap shoot set hole		Machining	Side					
1	L-20105500-M	**Sloped unit surface**		Machining	Side	2		L-20104000-M	L-20103000-M	
2	L-20105501-M	Die alignment		Die change	Side					
2	L-20105502-M	Trunk cam unit surface hole		Machining	Side					
2	L-20105503-M	Rear combination cam unit surface hole		Machining	Side					
1	L-20106000-M	**Insert assembly**		ASSY	ü Ü	2		L-20104000-M	L-20103000-I	L-20105500-M
2	L-20106001-M	Insert alignment		ASSY	ü Ü					
2	L-20106002-M	Insert assembly		ASSY	ü Ü					
1	L-20107000-M	**Insert knock**		Machining	Upper	2		L-20106000-M		
2	L-20107001-M	Insert alignment		Die change	Upper					
2	L-20107002-M	Insert set hole		Machining	Upper					
2	L-20107003-M	Insert knock pin		Machining	Upper					
2	L-20107004-M	Cam unit base knock pin		Machining	Upper					
1	L-20107500-M	**Die alignment**		Die change		2	ü ø	L-20107000-M		
2	L-20107501-M	Die alignment		Die change						
1	L-20108000-M	**Shape profile--rough**		Machining	Upper	2				
2	L-20108001-M	Insert cut line profile--rough		Machining	Upper					
2	L-20108002-M	Shape machining--rough		Machining	Upper					
2	L-20108003-M	Cut die single reference hole		Machining	Upper					
2	L-20108004-M	Cut die height reference		Machining	Upper					
2	L-20108005-M	Insert disassembly		Machining	Upper					
2	L-20108006-M	FC component cut line profile--finished		Machining	Upper					
2	L-20108007-M	FC component cut line beveling		Machining	Upper					
1	L-20109000-M	**Insert assembly**		ASSY		2		L-20108000-M		
2	L-20109001-M	Cut die insert reassembly		ASSY						

Figure 5-6 Example of machining process data

5.3.3.2.4 Study Items

The dies for all of the side outer panel press forming processes (blank process, draw process, trim process, first bend process, second bend process) were studied with the objective of automating the NC data calculations for the die plane_and_hole machining (flat surfaces, holes, taps, pockets, slots, etc.) by examining the following.

- What is the die related data required for automatic calculation of NC data for plane_and_hole machining ?
- Can this information be expressed without contradiction in the next UoF of the AP214?
    - Form feature (FF1, FF2, FF3)
    - Surface finish (C1)
    - Tolerance (T1,T2)

5.3.3.3 Mapping to the AP214 ARM

5.3.3.3.1 Die Data Basic Construction Portion Instance

5.3.3.3.1.1 DDID Level Instance

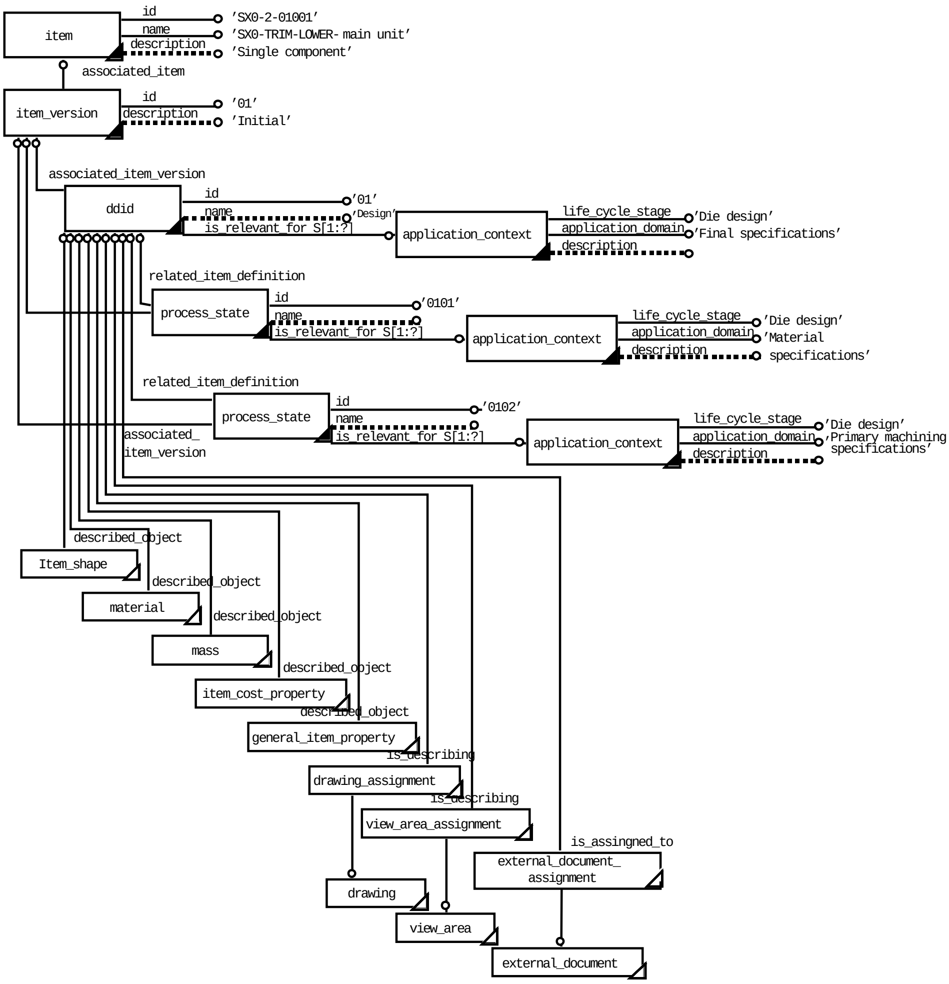

Figure 5-7 DDID level instance

The final specifications are the final die specifications and express the final shape, machining areas, tolerance, surface finish, materials, and weight, etc., and the material specifications are the pre-machining die specifications and express the material shape and machining allowance, etc.

For the material specifications method there is the method that adds the material machining allowance using shape_aspect linked to each face of the final specifications shape in addition to the method that is clearly expressed at the DDID level as shown in Figure 5-7,.

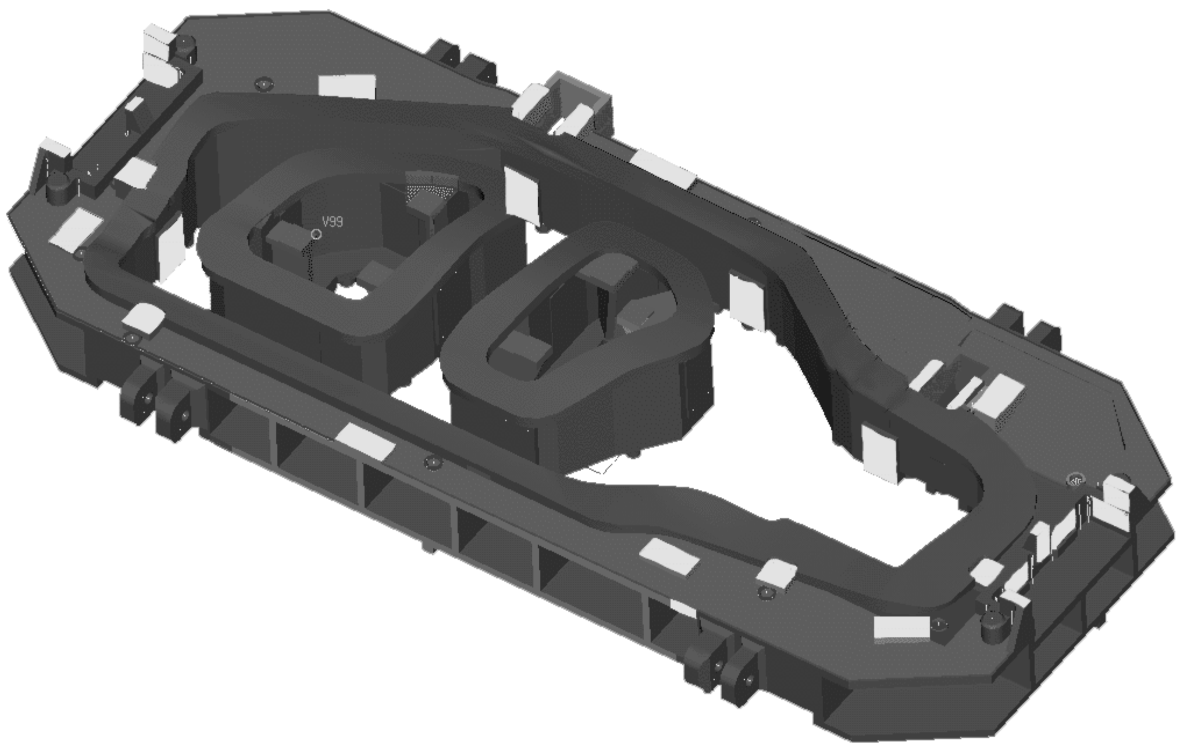

Figure 5-8 Example of Item_shape

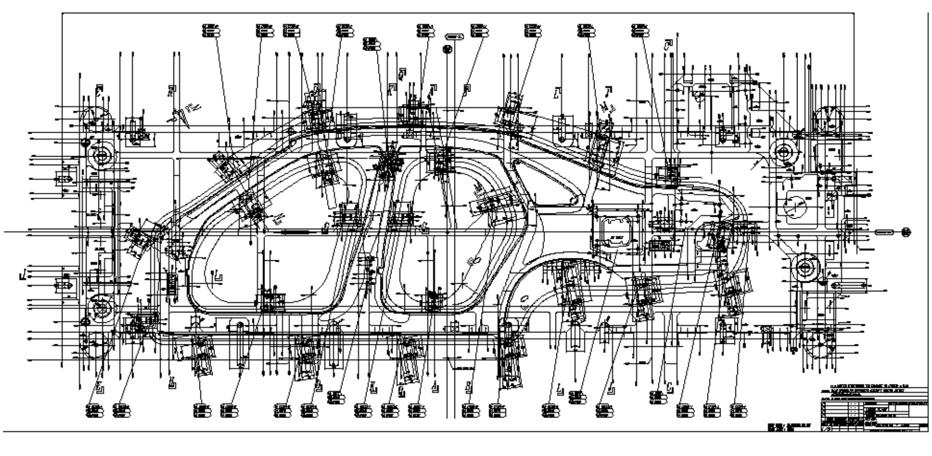

Figure 5-9 Example of Drawing

5.3.3.3.1.2 Featured_shape construction (features without shape)

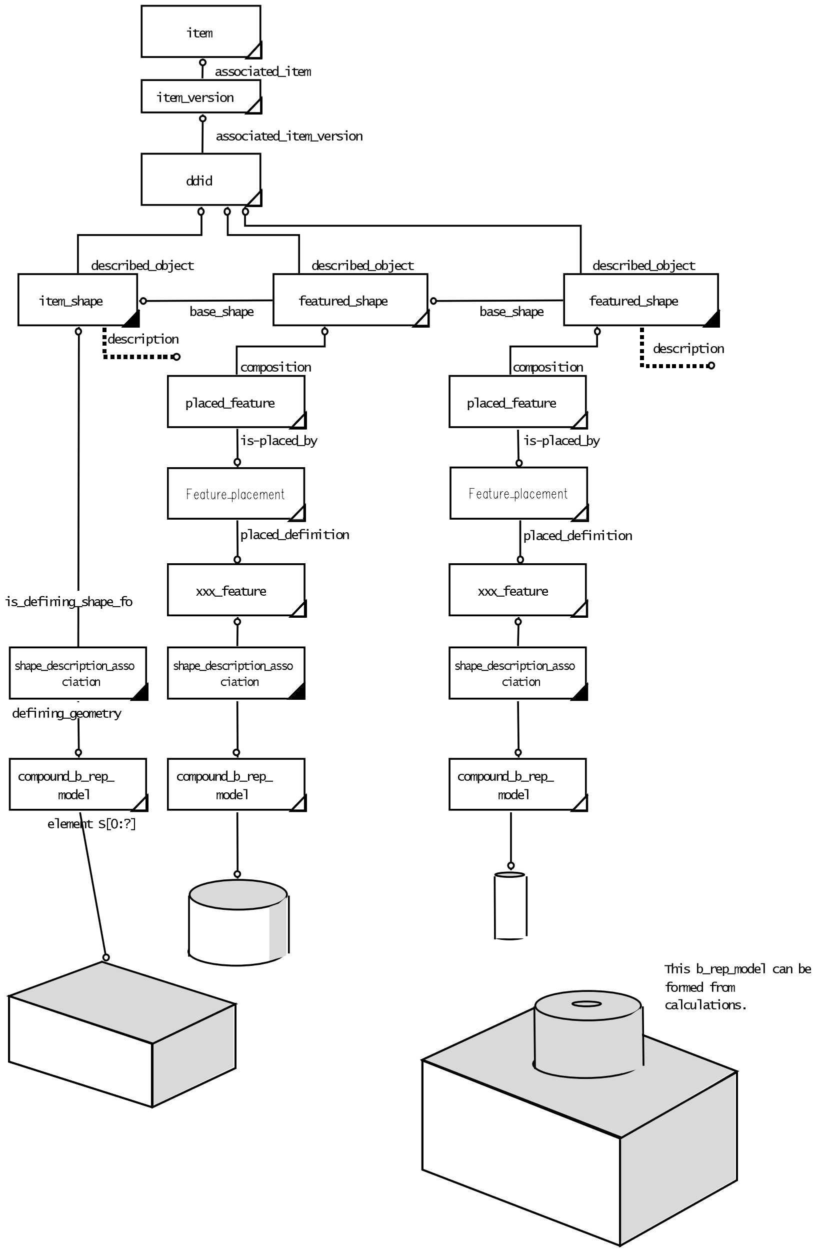

Figure 5-10 Featured_shape without shape

Here, the construction around the featured_shape makes an instance of a general model as an example.

Figure 5-10 shows the case when a feature without shape is used.

This construction expresses the information required to regenerate the shape by changing the feature's parameters, etc.

If we consider that in CAM the component shape is generally not regenerated, it could be thought to be meaningless to use this construction as CAM input. However, if the hole and tap defined feature information exists when machining holes and taps, then there are times when the component's final shape is not required, so this construction is effect as simple data that can be used by CAM.

5.3.3.3.1.3 Featured_shape construction (Feature with shape)

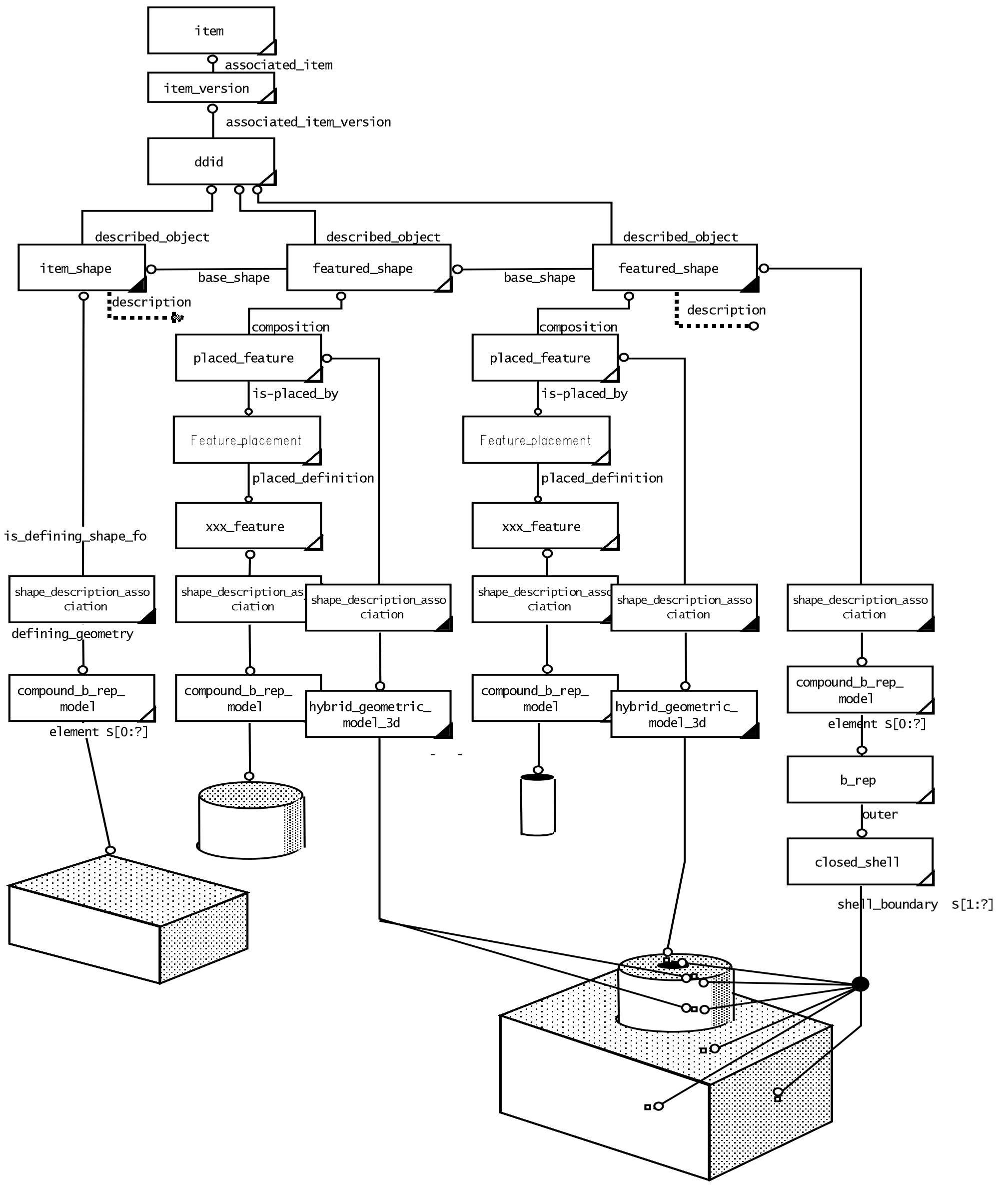

Figure 5-11 Featured_shape with shape

This is the construction around the featured_shape when feature with shape is used.

Because the information for regeneration is not needed when received by CAM, we deemed that this method cannot be used.

5.3.3.3.1.4 Item_Shape Construction without Featured_shape

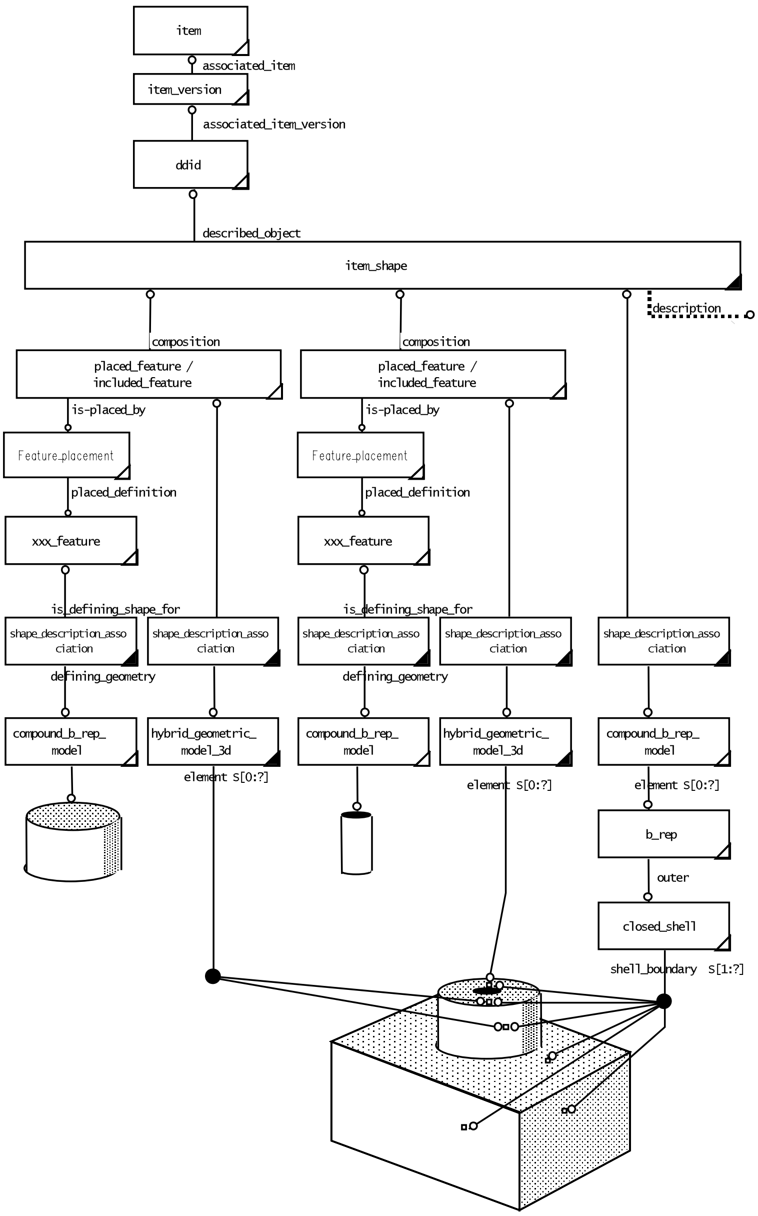

Figure 5-12 Item_Shape Construction without Featured_shape

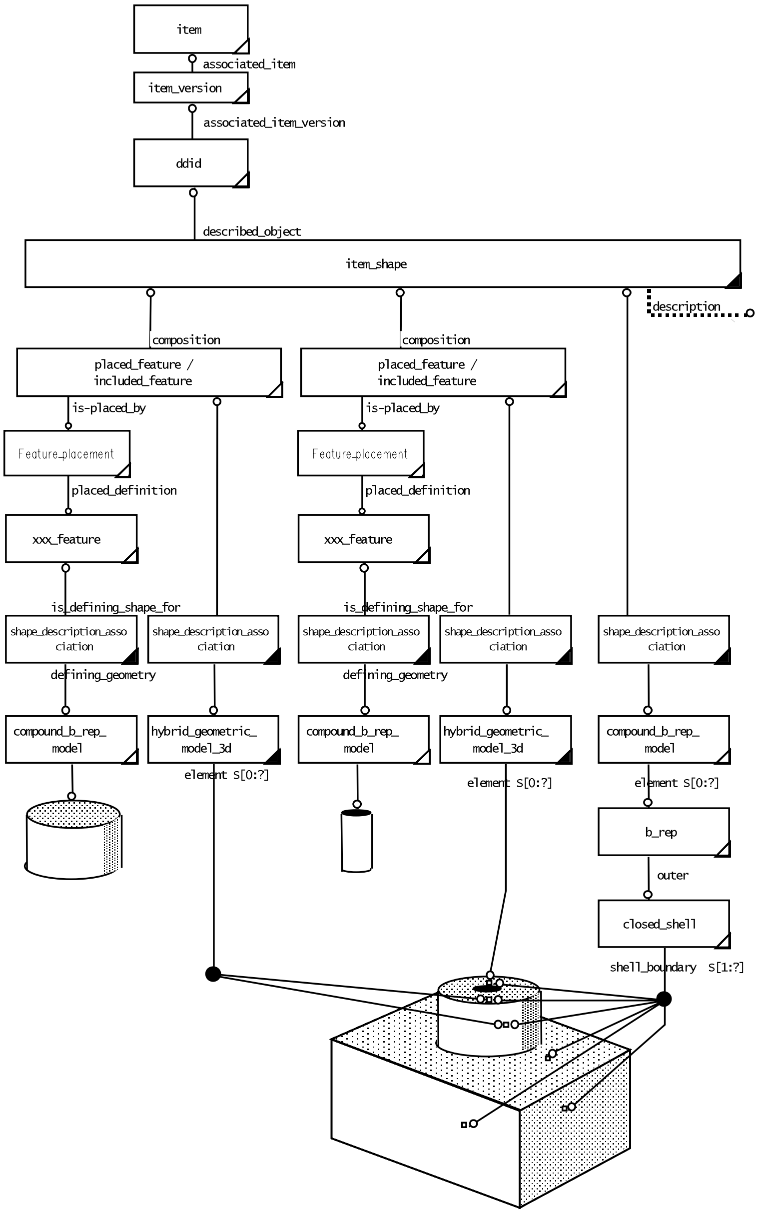

Figure 5-12 shows an example of the general construction around item_shape without featured_shape. There is no information for shape re-generation.

Generally, this method of expression can be used when received by CAM.

5.3.3.3.1.5 Roughness Construction (Feature Without Shape)

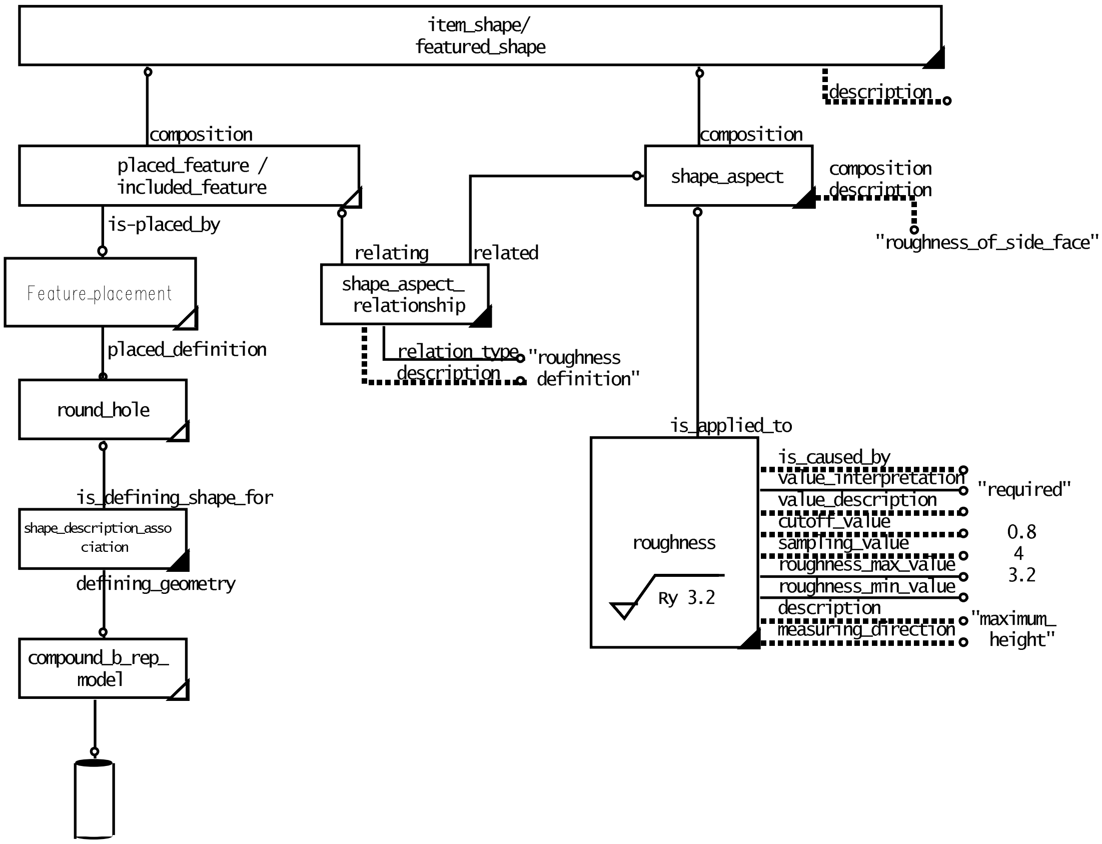

Figure 5-13 Roughness without Shape

This shows a general example of roughness.

For feature without shape the main issue, for example, is that it is unclear what is the round_hole side roughness. This can only be shown suggestively by specifying the comment "roughness_of_side_face" in the shape_aspect description attributes.

5.3.3.3.1.6 Roughness Construction (Feature With Shape)•

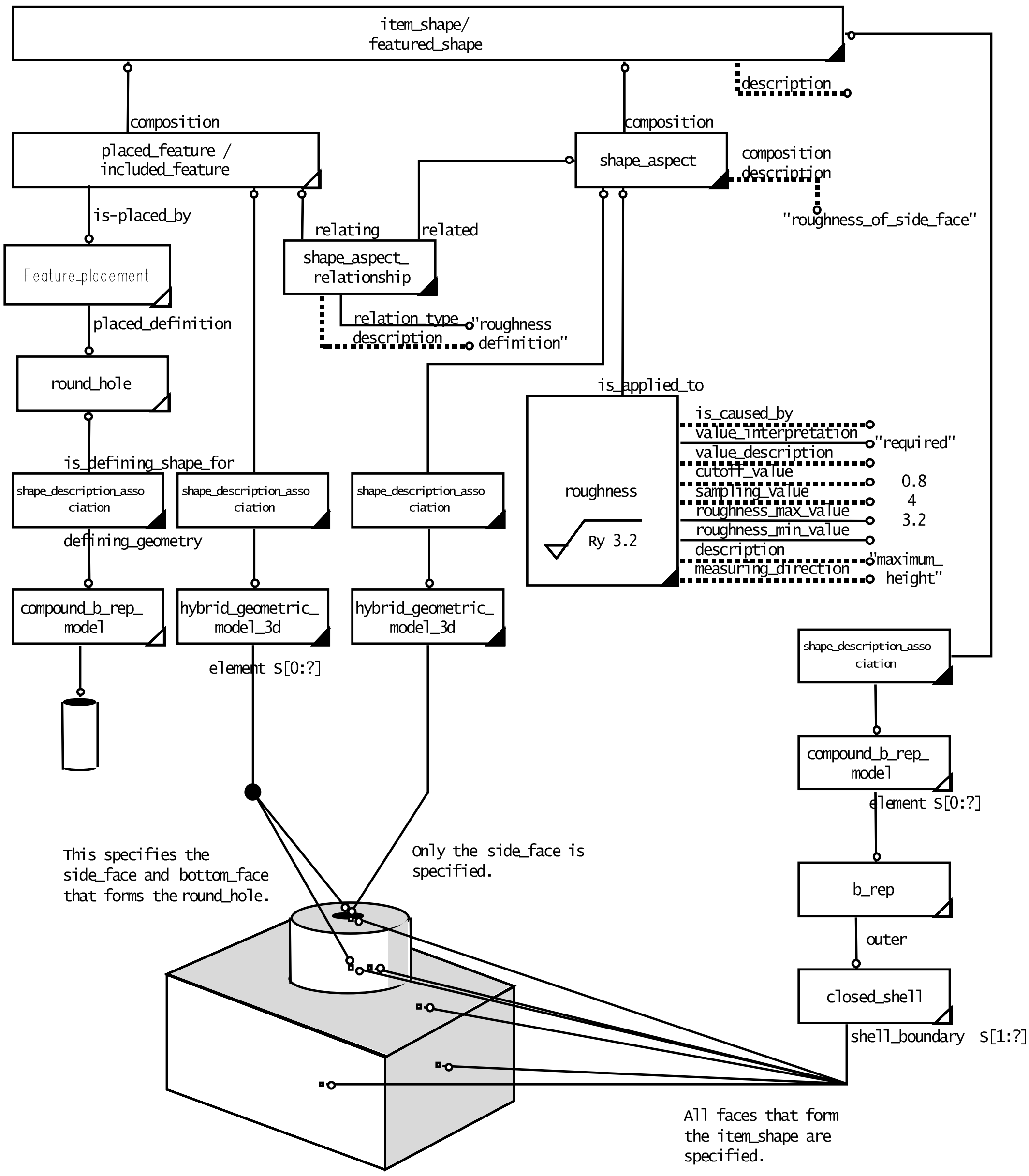

Figure 5-14 Roughness with Shape

When the feature has shape it is possible to see what is the roughness related to the face to determine what is the roughness of, for example, the round_hole side face by searching regarding the faces that form the feature and specifying the face on the side face.

The face attribute values must be searched to automatically specify which face is the side face.

5.3.3.3.2 Correlation of Design Elements to Form Features

Form Feature / Design Element	compound	replicate			slot	pocket			boss			round_hole	rib	thread	general	Made into an Instance
		rectangular	circular	general		rectangular_closed	rectangular_open	general	circular	rectangular	general					
Tightening seat	O				O					O						4.1.2.3.3.1
Location pin groove	O				O											4.1.2.3.3.2
Guide post hole	O								O			O				4.1.2.3.3.3
Guide plate installation seat															O	4.1.2.3.3.4
Cylinder seat for panel removal	O				O							O				4.1.2.3.3.5
Distance plate tightening bolt hole	O	O										O		O		4.1.2.3.3.6
Processing reference hole				O								O				4.1.2.3.3.7
Limit switch pocket						O										4.1.2.3.3.8
Pierce pin hole	O											O				4.1.2.3.3.9
Scrap cutter seat										O						4.1.2.3.3.10
Guide surface															O	4.1.2.3.3.12
Insert pocket							O									4.1.2.3.3.13
Side pin seat	O								O			O				4.1.2.3.3.15
Side pin groove	O					O						O				
Coordinate hole												O				
Scrap cutter set hole	O	O										O		O		
Cam unit surface															O	
Cam single unit reference hole												O				
Cam side reference hole												O				
Guide insert set hole	O	O										O		O		
Driver surface															O	
List insert location pin reference hole												O				
Pierce punch center knock hole												O				
Pierce punch retainer set hole												O				
Cutter seat peg in door								O								
Rear escape															O	
Pierce straight hole												O				
List up hole												O				
BH striper bolt hole	O			O								O		O		
BH striper bolt seat															O	
Blank slide surface															O	
Spring plunger	O											O		O		
Bottoming mark								O								
Stamp punch hole												O				
Angle rest escape					O											
Distance plate reception surface															O	
Bumper dimpled punch hole	O			O								O		O		
F/P insert driver surface															O	
Pattern die peg												O				
Button die hole												O				
Lifting cam single unit reference hole												O				
Lifting cam guide reference hole												O				
Center knock hole												O				
Retainer set hole	O											O		O		
Pierce hole	O							O				O				

Figure 5-15 Correlation of Design Elements to Form Features

The design elements for the plane_and_hole machining for the dies required for all press form processing for the side outer panel are shown in Figure 5-15. Of these, we tested creating instances for 13 design elements. Since we found that the remaining design elements will become the same instances, we omitted making them instances.

5.3.3.3.3 Instances for Each Design Element

5.3.3.3.3.1 Tightening Seat

The tightening seat is the surface used when installing the die main unit (upper die and lower die) in the press machine holder and ram. Several of these seats are made on both the upper and lower dies.

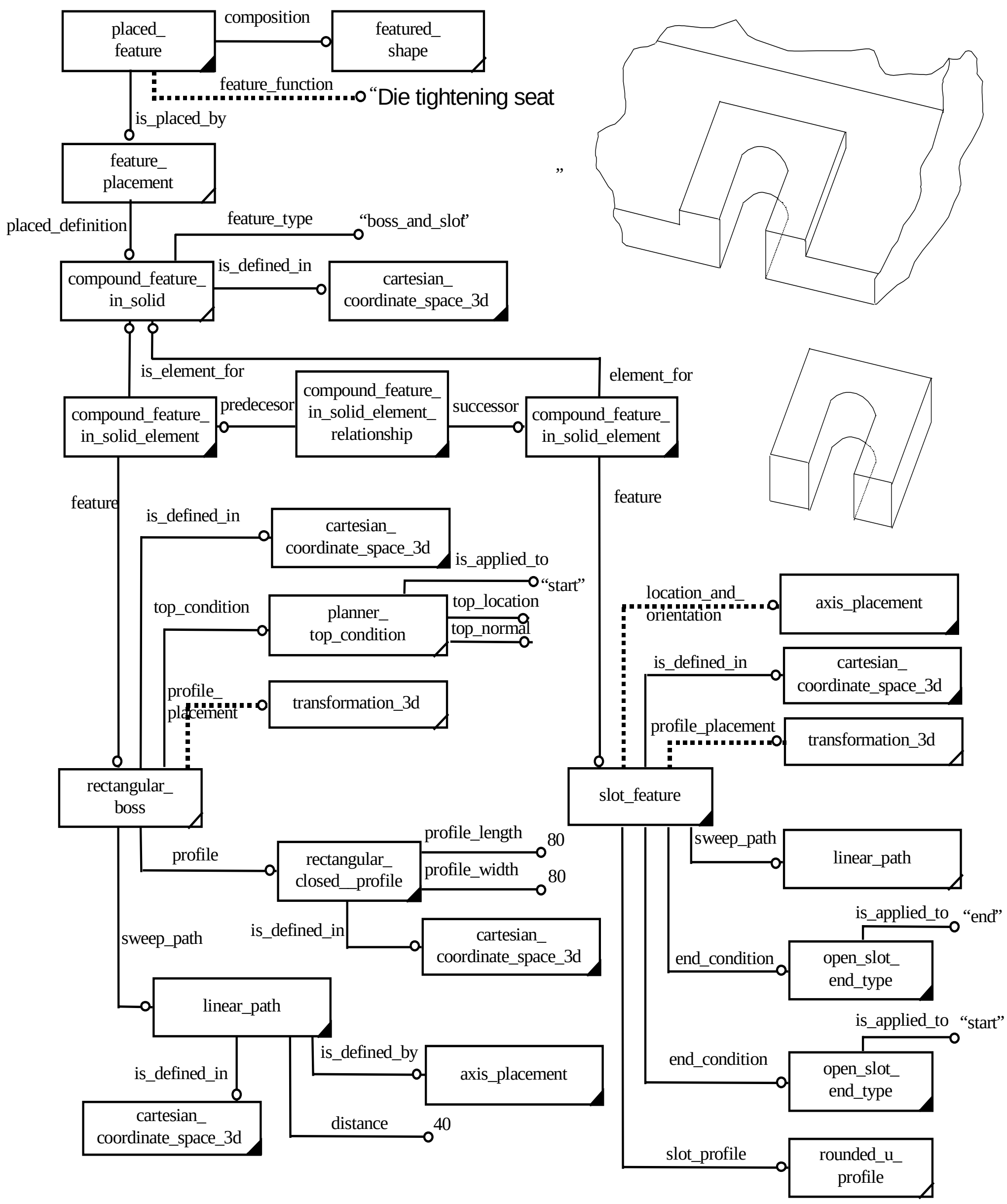

Figure 5-16 Tightening seat

5.3.3.3.3.2 Location Pin Groove

The location pin groove is used to position the die when setting it in the press machine and the groove shape is made in the die for positioning by sliding over the bolster placed in the press machine in advance. There are two location pin grooves on the lower die.

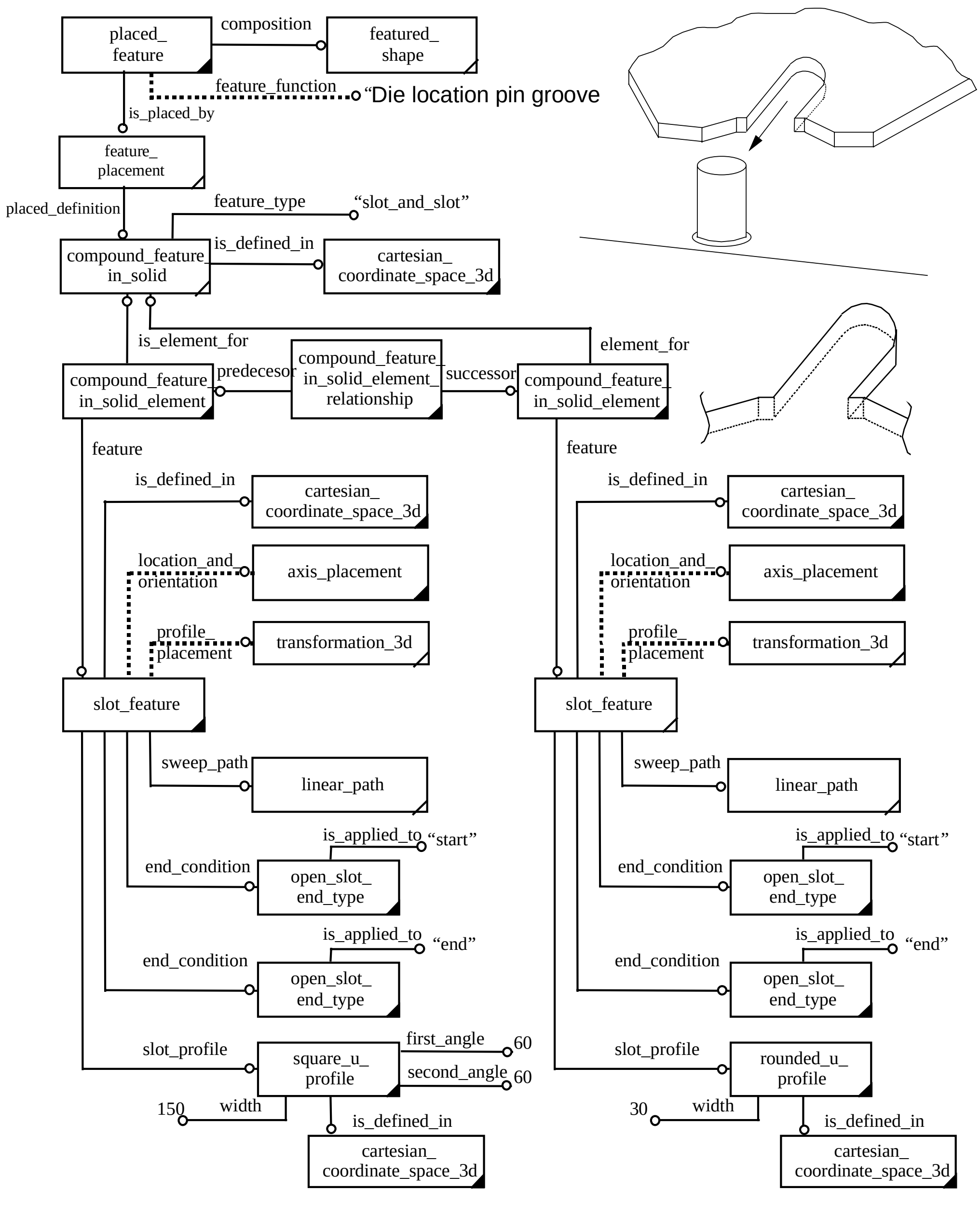

Figure 5-17 Location pin grooves

5.3.3.3.3.3 Guide Post Holes (Upper Die, Lower Die)

The guide post hole is a hole in which is placed the guide post that correctly aligns the upper and lower dies.

Four are placed in both the upper die and lower die.

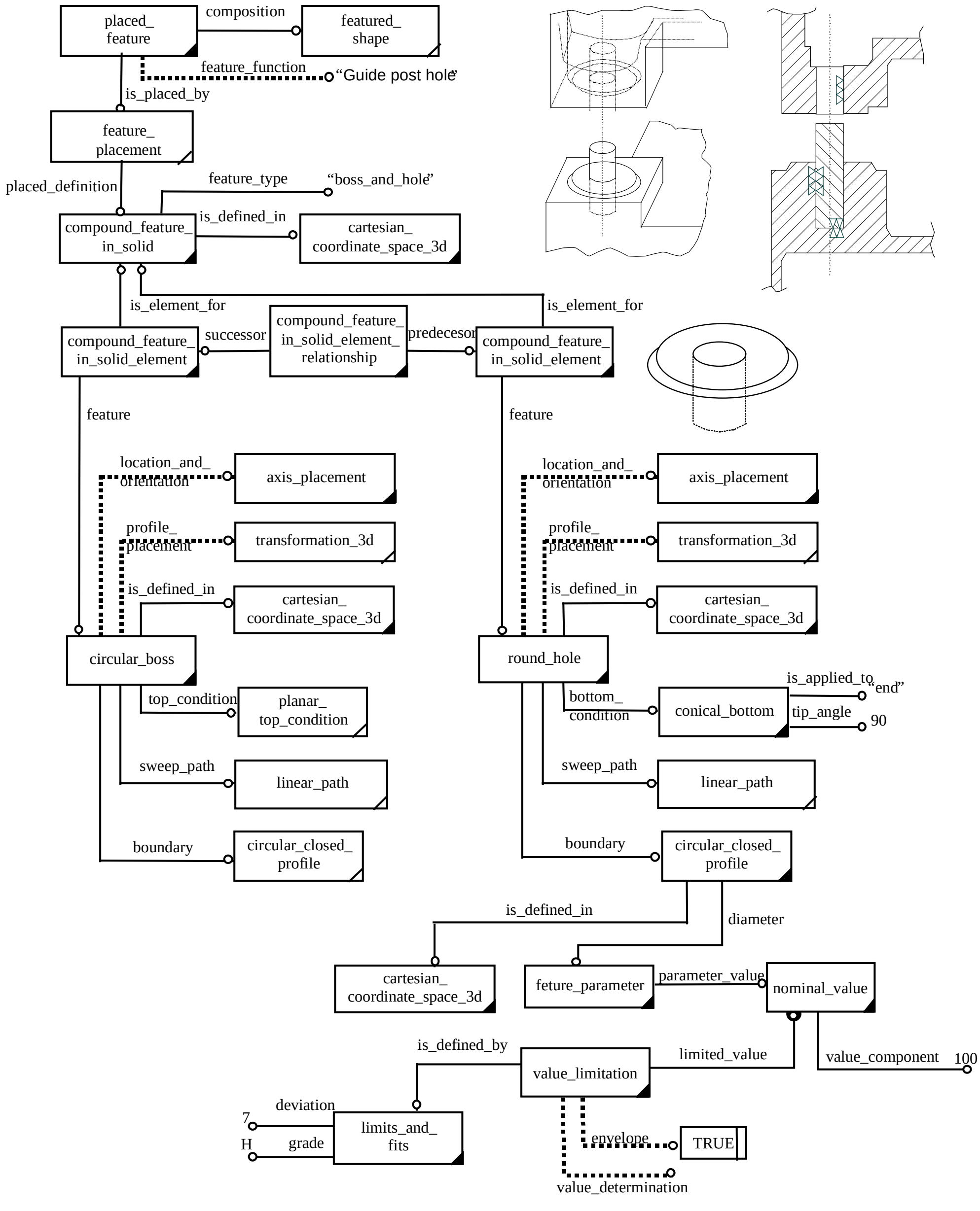

Figure 5-18 Guide post hole

5.3.3.3.3.4 Guide Plate Installation Seat

The guide plate installation seat is the shape that installes a guide plate to correctly align the upper and lower dies.

The guide plate serves basically the same function as the guide post but is used when larger eccentric loads are received.

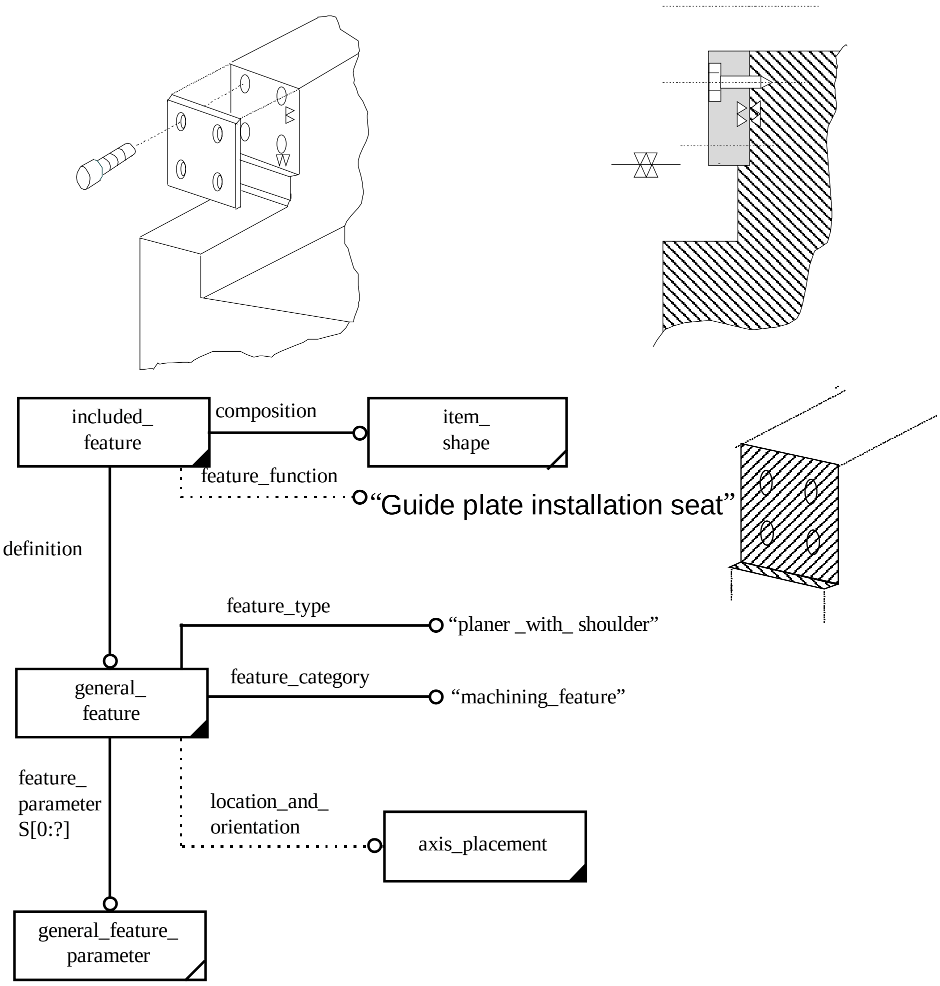

Figure 5-19 Guide plate installation seat (No.1)

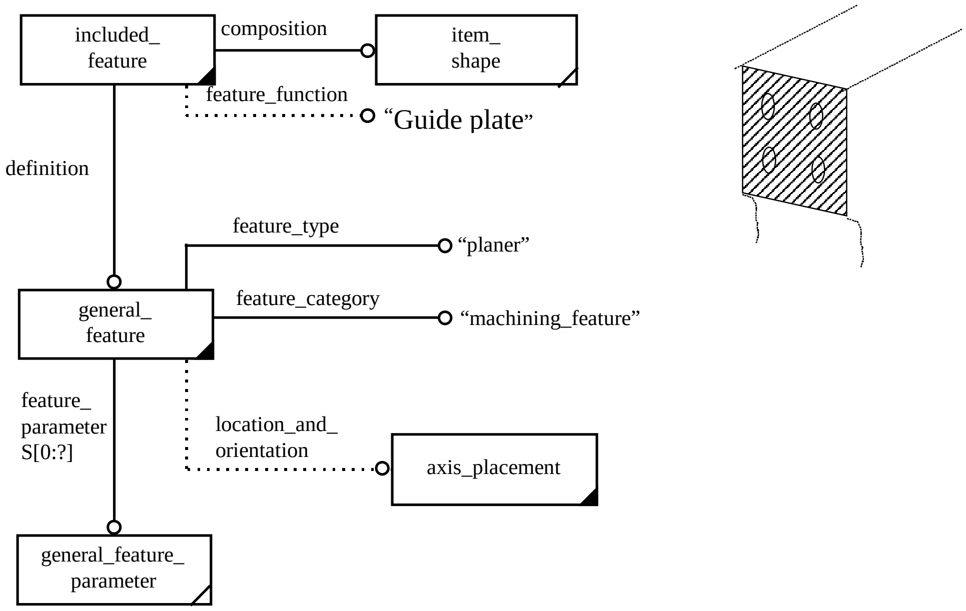

Figure 5-20 Guide plate installation seat (No.2)

5.3.3.3.3.5 Panel Removal Cylinder Seat

Removal mechanisms that use air cylinders are frequently used to remove the finished panel from the die.

The seat in this example is one that is generally used for installing the cylinders that remove the panel.

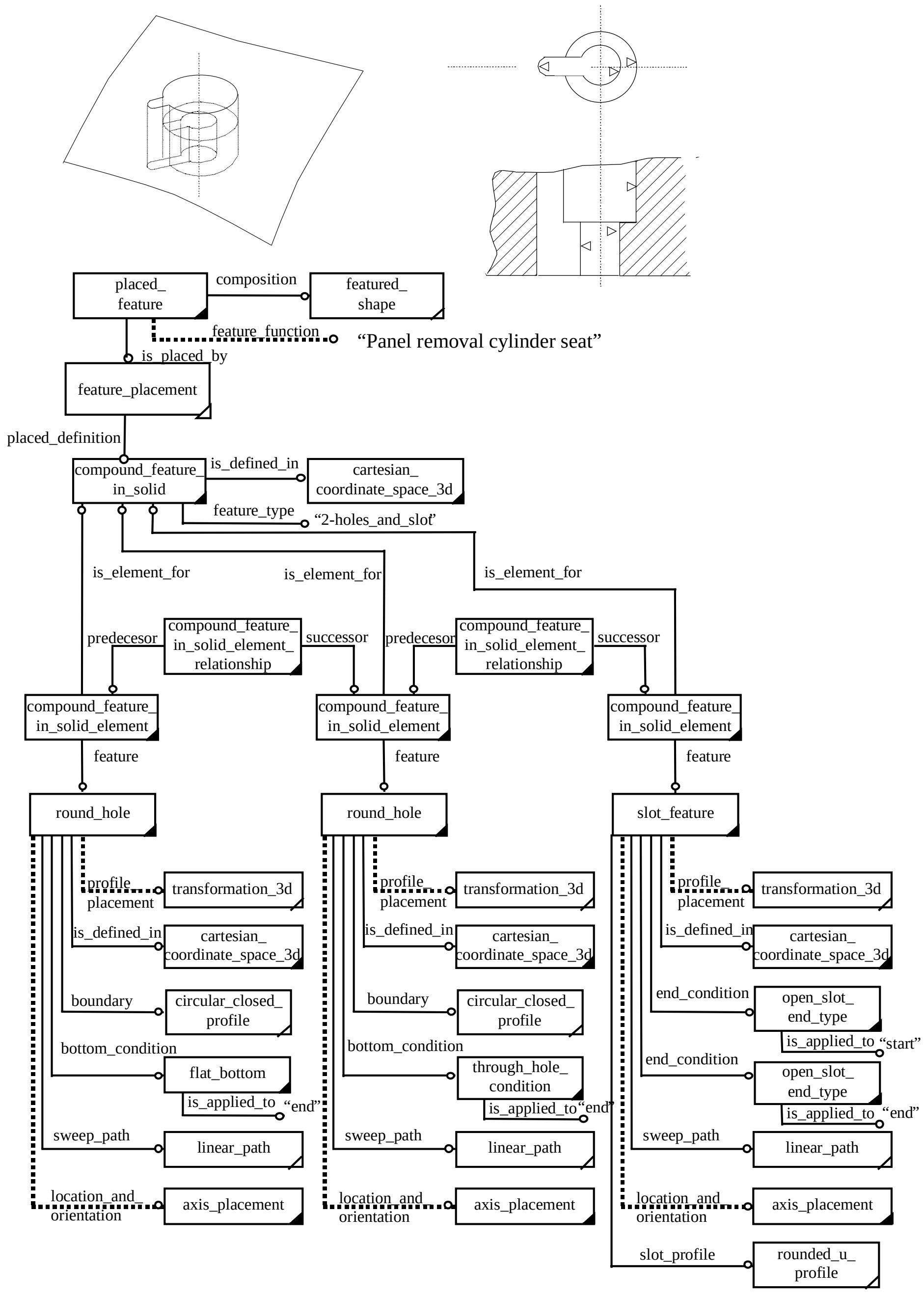

Figure 5-21 Panel removal cylinder seat

5.3.3.3.3.6 Distance Plate Tightening Bolt Hole

A representative example of the distance plate is that part which adjusts and holds steady the gap between the upper and lower dies during the press form bottom dead point.

On the press die are many plates like that shown in this example and these are installed on the die main unit.

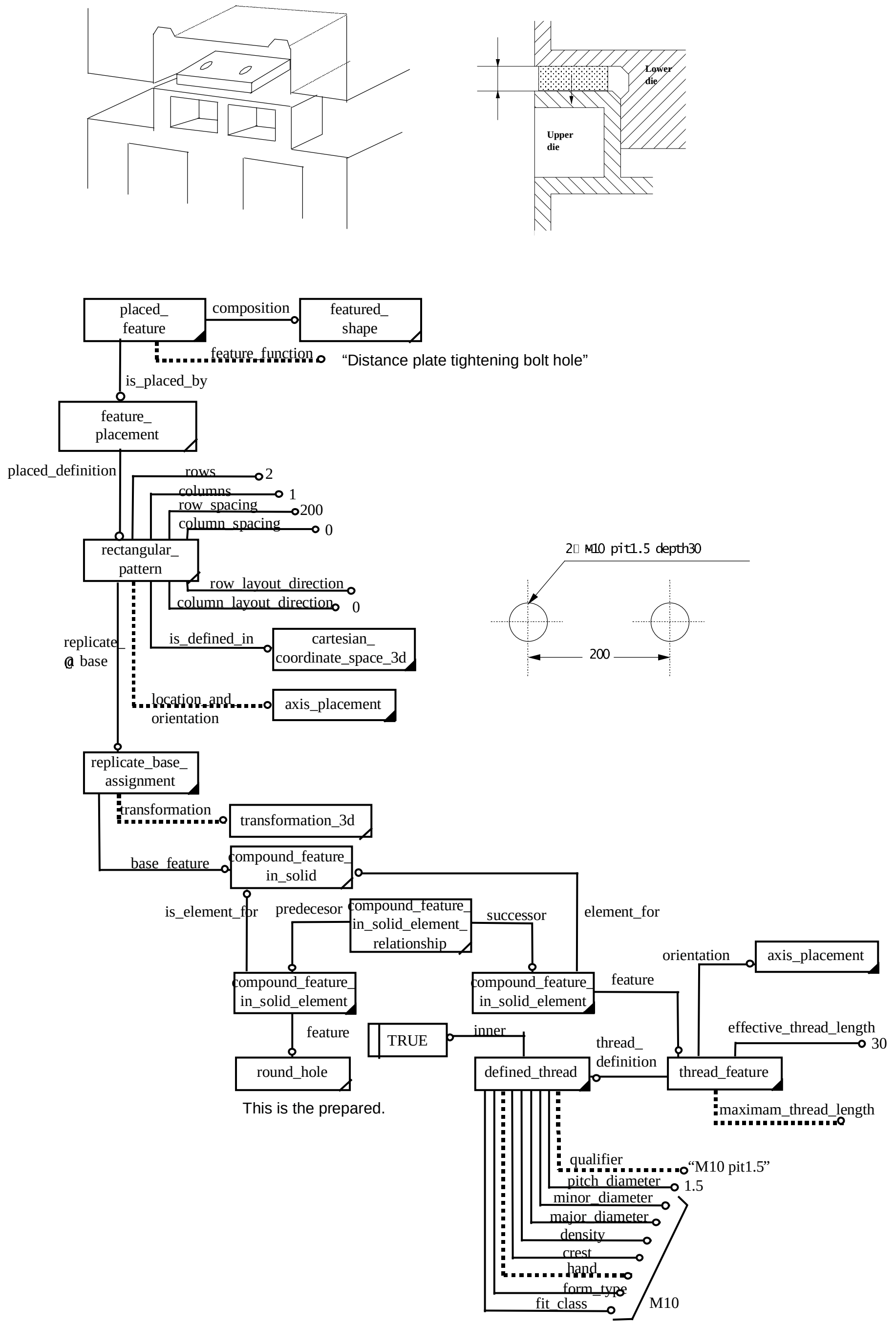

Figure 5-22 Distance plate tightening bolt hole

5.3.3.3.3.7 Machining Reference Hole

The machining reference hole is the hole that is used to align the coordinates with the machine during die machining.

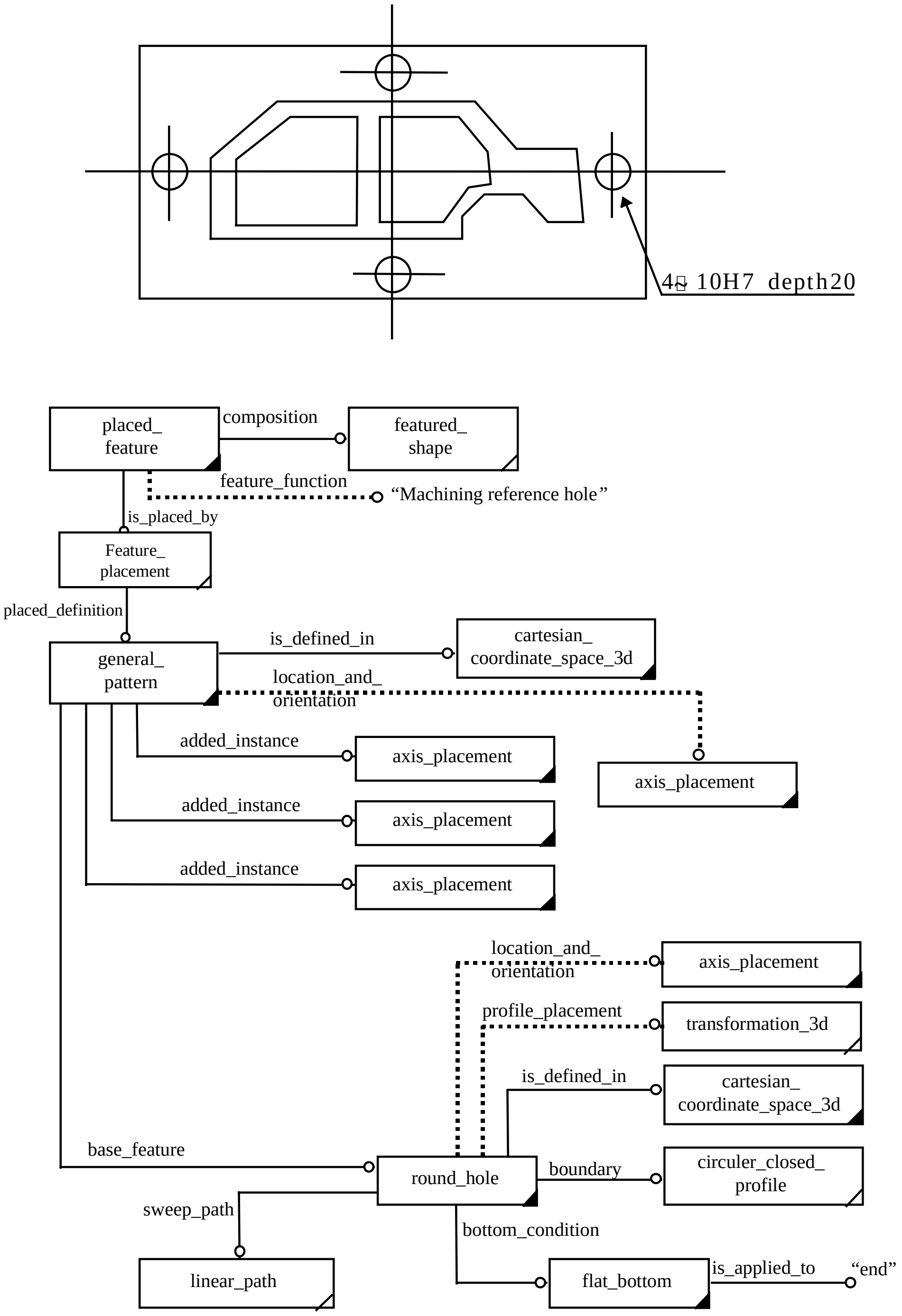

Figure 5-23 Machining reference hole

5.3.3.3.3.8 Limit Switch Pocket

The limit switch pocket is the pocket shape in which the limit switch is placed.

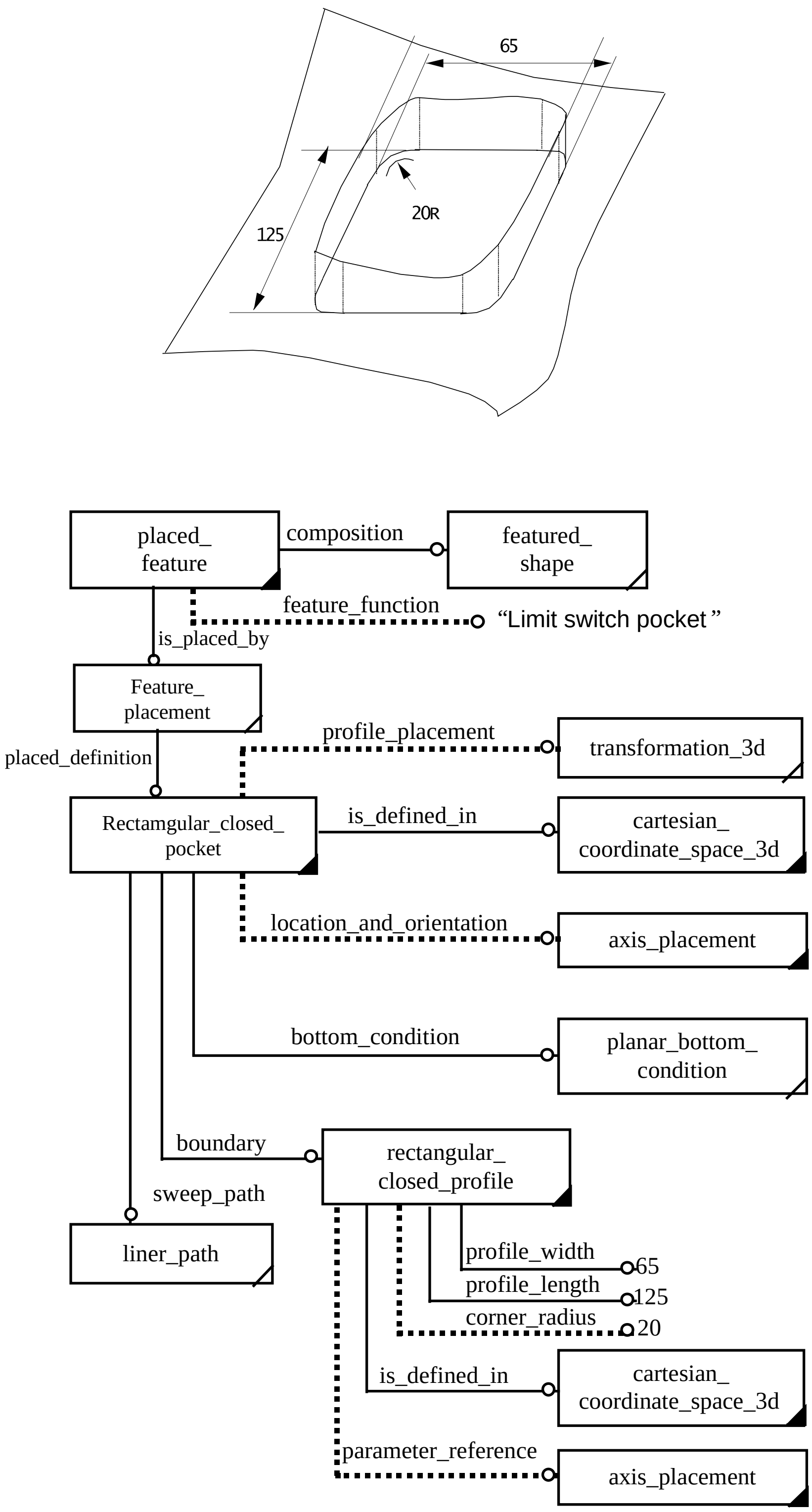

Figure 5-24 Limit switch pocket

5.3.3.3.3.9 Pierce Hole

The pierce hole is the hole in which the pierce button die is inserted and the knock hole that prevents the button die from rotating.

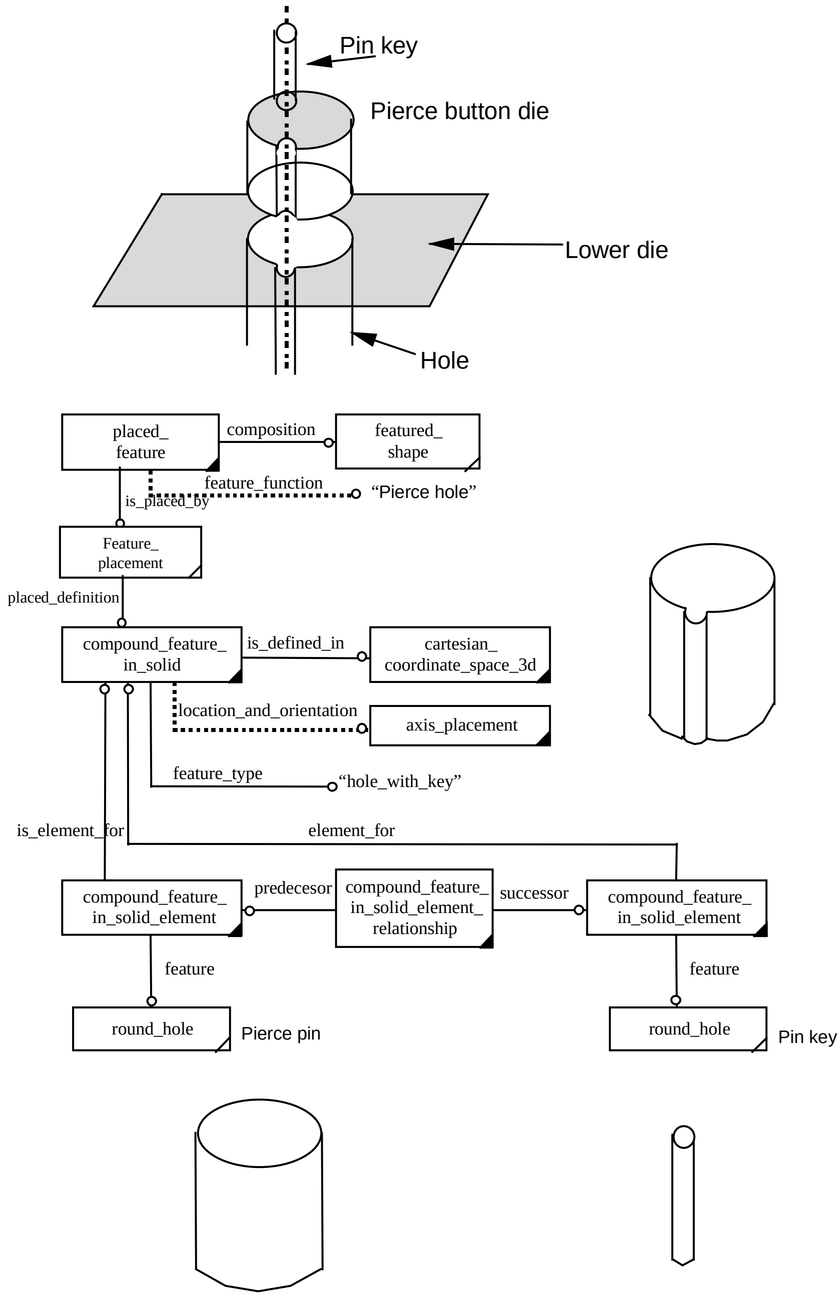

Figure 5-25 Pierce hole

5.3.3.3.3.10 Scrap Cutter Seat

The scrap cutter is used to cut off the excess sheet steel from around the formed part after the draw process.

The scrap cutter seat is the seat to which the scrap cutter is installed.

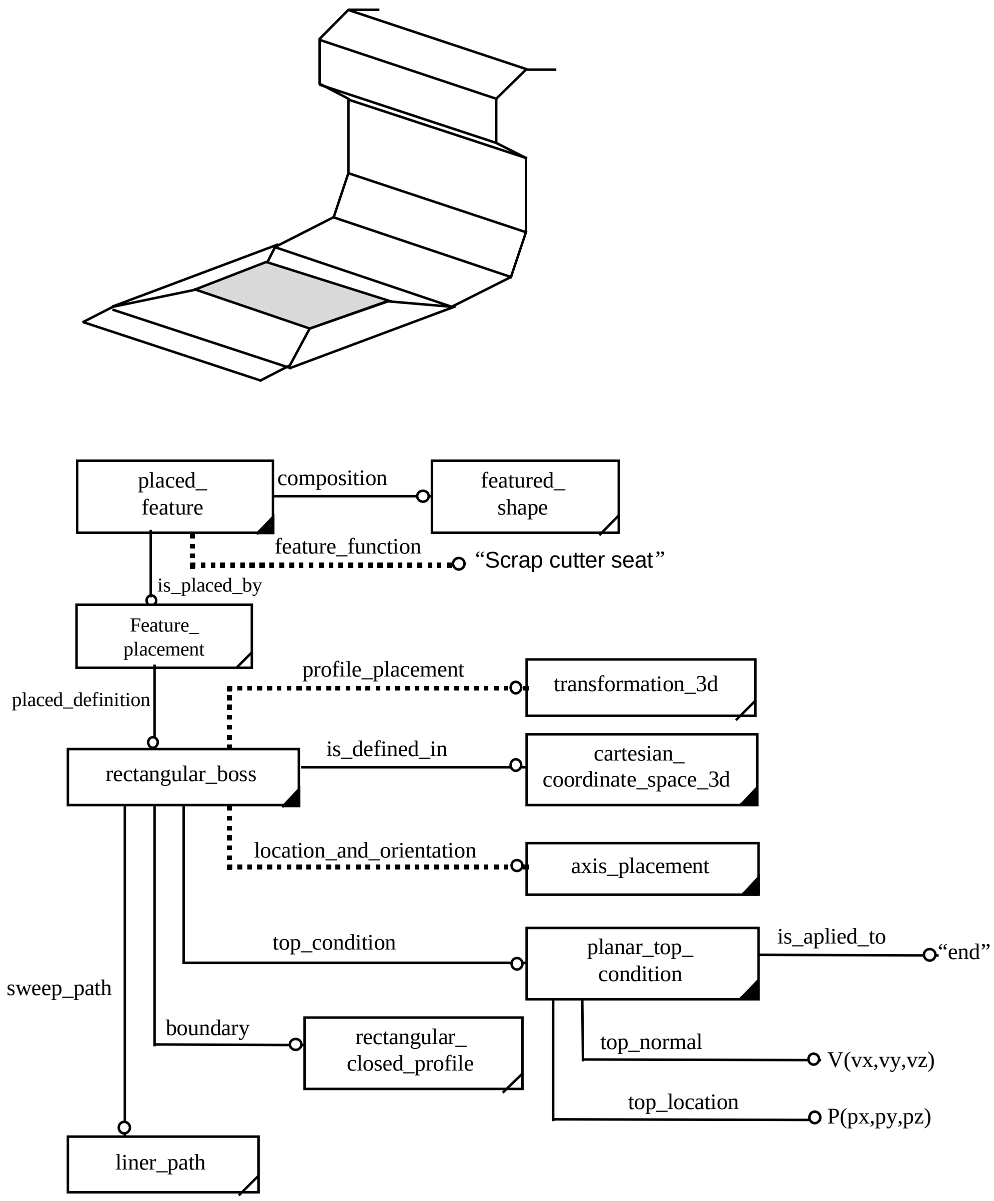

Figure 5-26 Scrap cutter seat

5.3.3.3.3.11 Scrap Cutter Set Hole

The scrap cutter set hole is the positioning hole in the scrap cutter seat that is used to assure accurate installation of the scrap cutter.

5.3.3.3.3.12 Guide Surface

The guide surface maintains the concentricity of the upper and lower dies.

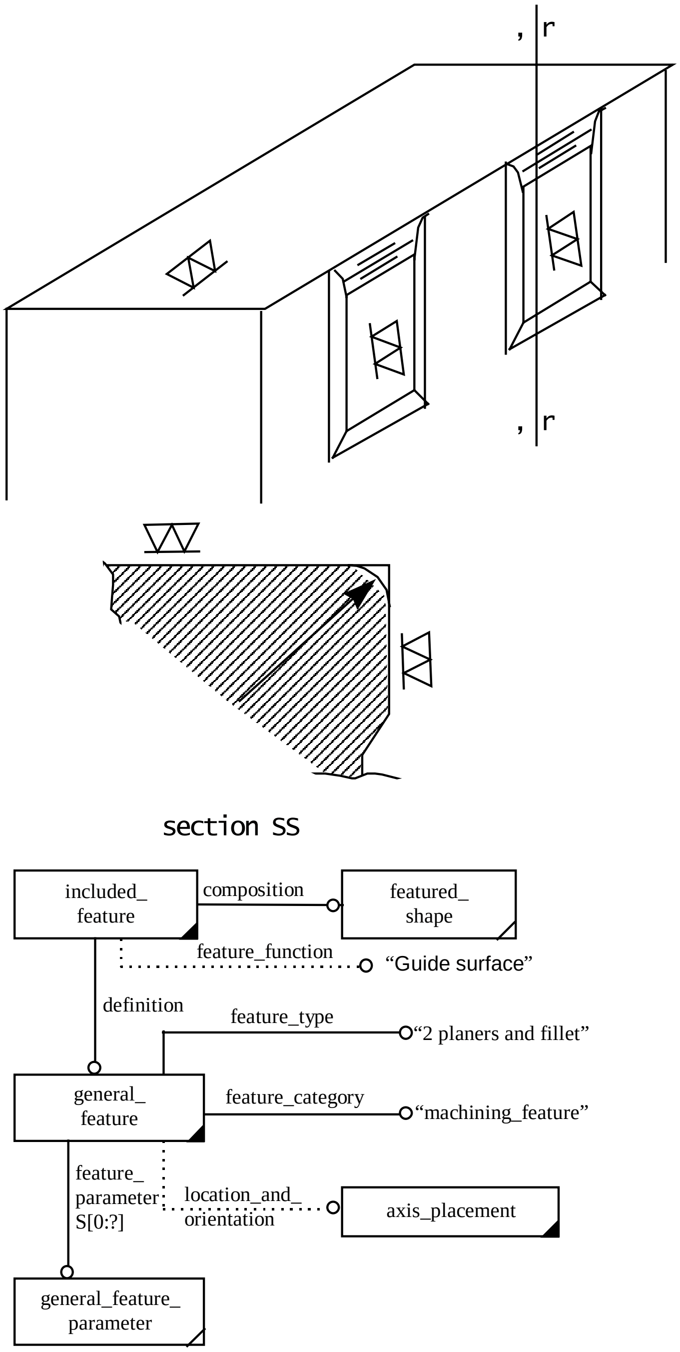

Figure 5-27 Guide surface

5.3.3.3.3.13 Insert Pocket

The insert pocket is the pocket shape in which is installed the block (called insert) that is used to construct part of the die (main unit).

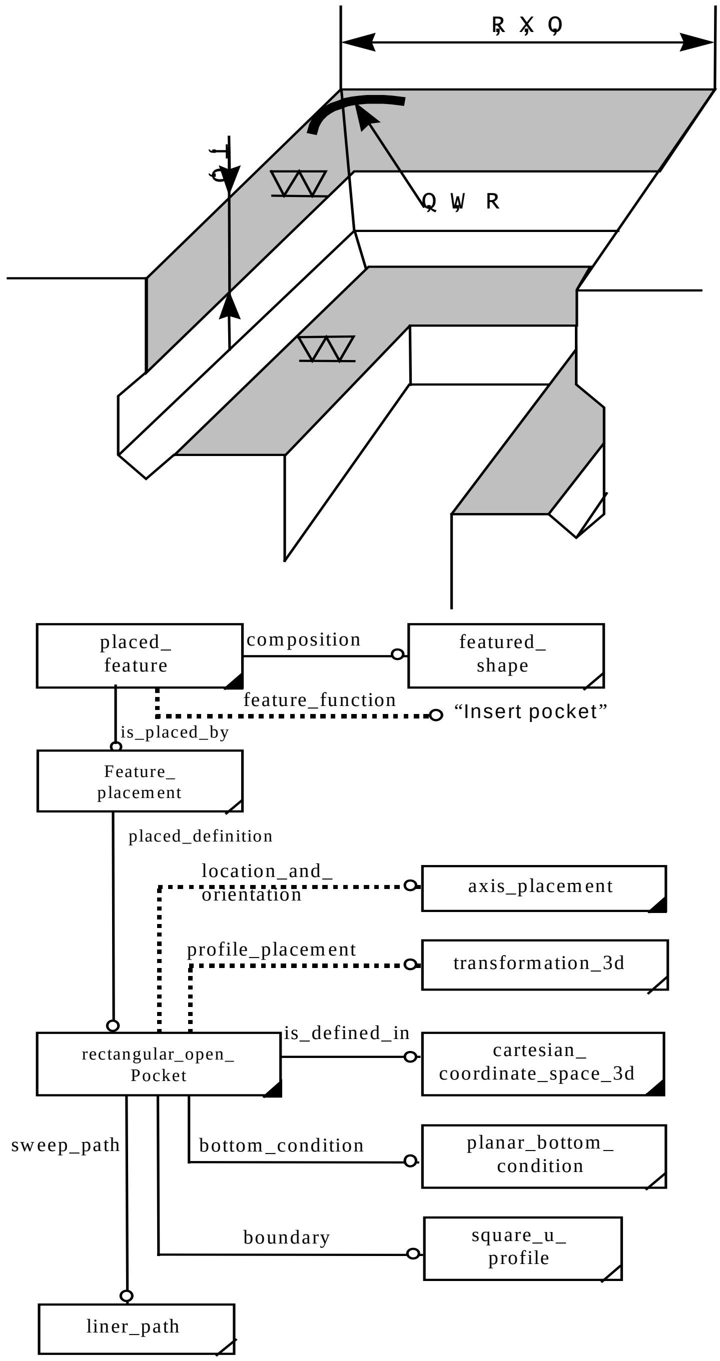

Figure 5-28 Insert pocket

5.3.3.3.3.14 Continuous Insert Pocket

In this example the compound_feature that has a shape that consists of three rectangular_pocket and four round_hole elements can be expressed.

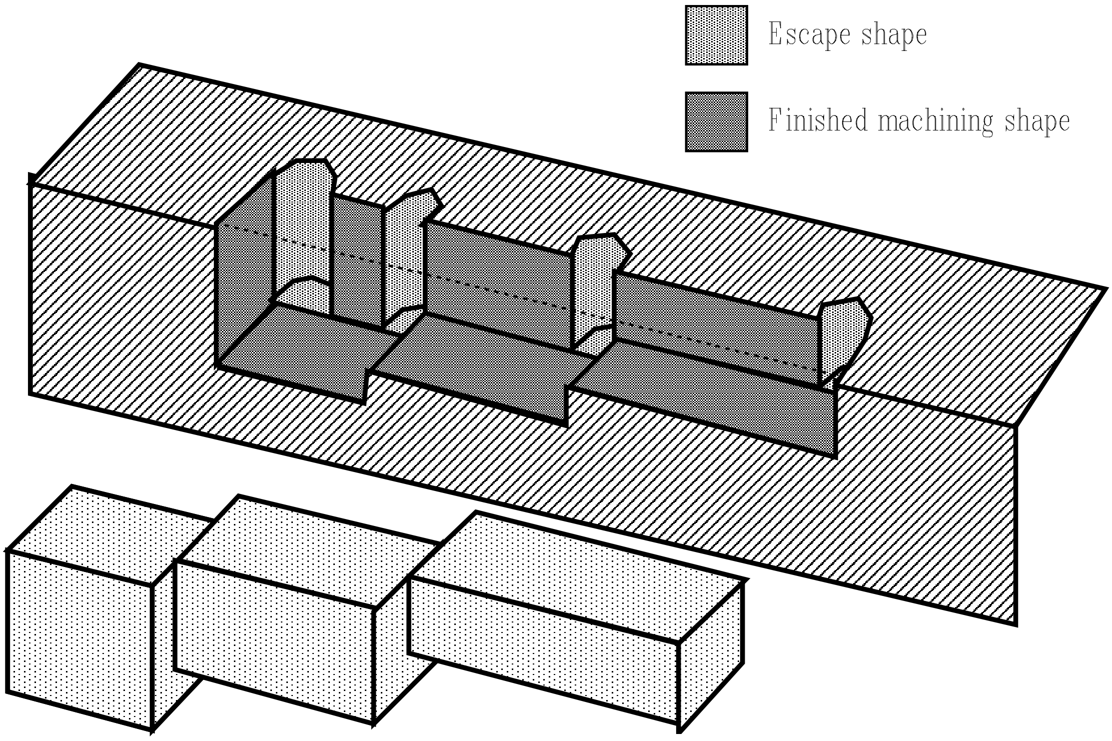

Figure 5-29 Continuous insert component pocket

5.3.3.3.3.15 Side Pin Seat

The mechanism called a side pin is used to determine correct stroke of pad in relation to upper die (during the die stroke) and to lock the upper die and the pad die. (during the die stock)

The side pin mechanism consists of the side pin, upper die side pin seat, and the side pin groove in the pad die.

The side pin seat consists of the seats (bosses) on both sides of the upper die rib and the hole into which the side pin is inserted.

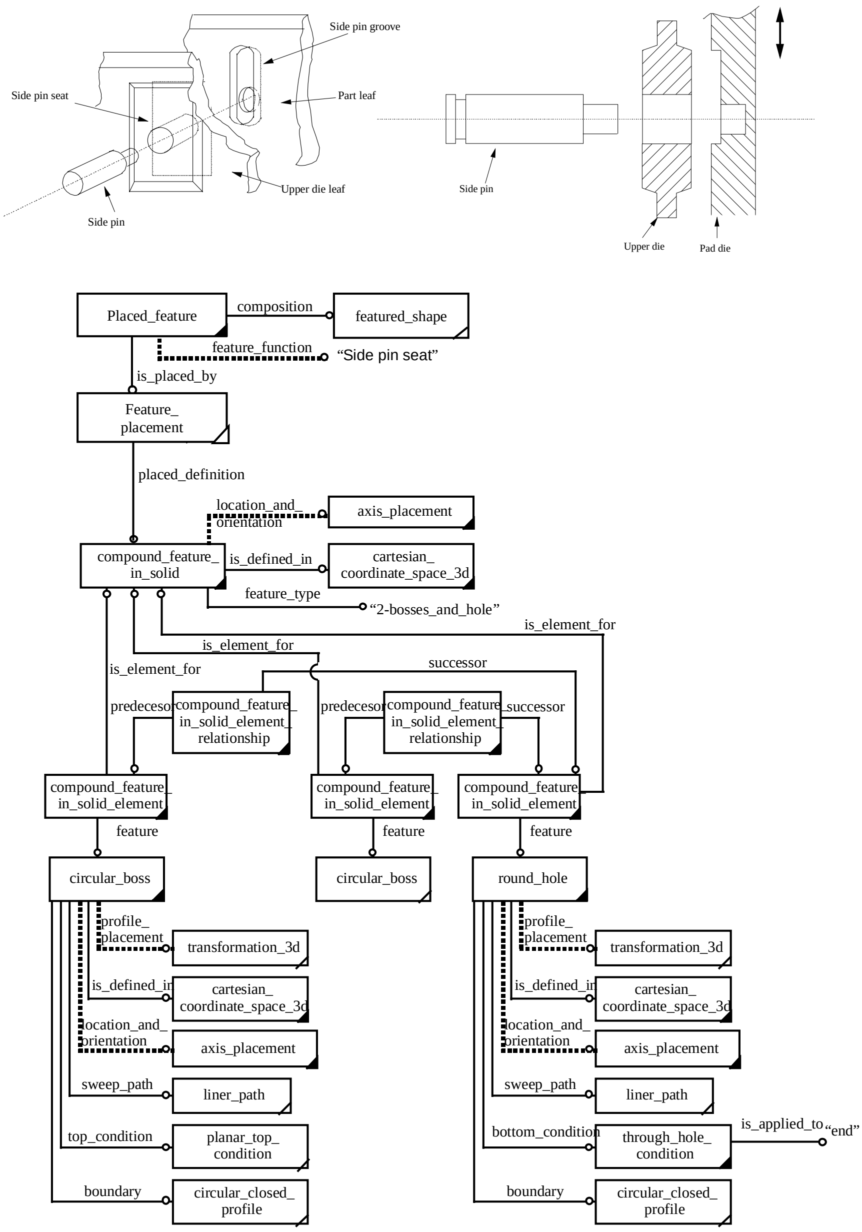

Figure 5-30 Side pin seat

5.3.3.4 Discussion

Using the press die that forms the side outer panel as a case study and testing the data from mainly the form features from the die design process to the die manufacturing process, we studied whether this would contribute to rationalization of plane_and_hole machining NC calculations.

The main die design informations that are required for NC calculations for press die plane_and_hole machining are listed below.

- Die finished specifications
  - (a) Finished shape
  - (b) Material characteristics
  - (c) Machining information
    - (c-1) Machining area
    - (c-2) Machining surface characteristics
    - (c-3) Tolerances
    - (c-4) Surface finish
    - (c-5) Entrance surface characteristics
  - (d) Material escape information
- Die pre-machining material specifications
  - (e) Material shape
  - (f) Material machining allowance

Of this information, there were no problems expressing (a), (b), and (e) in ARM.

(c-1) and (c-2) can be expressed in form features.

For (c-3) there were no problems expressing in ARM the ranges found in splane_and_hole machining.

For (c-4) there were technical issues. (Refer to Items 5.3.3.3.1.5 and 5.3.3.3.1.6)

For (c-5), (d), and (f) there were no problems expressing these in ARM.

In the future, in addition to a desktop study we will develop a CAM system prototype based on the form features and then test this information in hopes of verifying that it will contribute to the automation of NC calculations.

5.3.4 HONDA: Process Plan for Equipment Design

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Created: September 1, 1998

Reference document: ISO TC184/SC4/WG3 N756

5.3.4.1 Abstract

We are studying whether or not it is suitable to express process plan data, which is output from the process design and input to detail designs for the development of special large equipment for automobile mass production equipment, such as press dies, welding equipment (Figure 5-1), and engine machining equipment, using the AP214's ARM. For this study we used multiple subjects with differing characteristics and that were systematically positioned to identify the differences in the process plan structure.

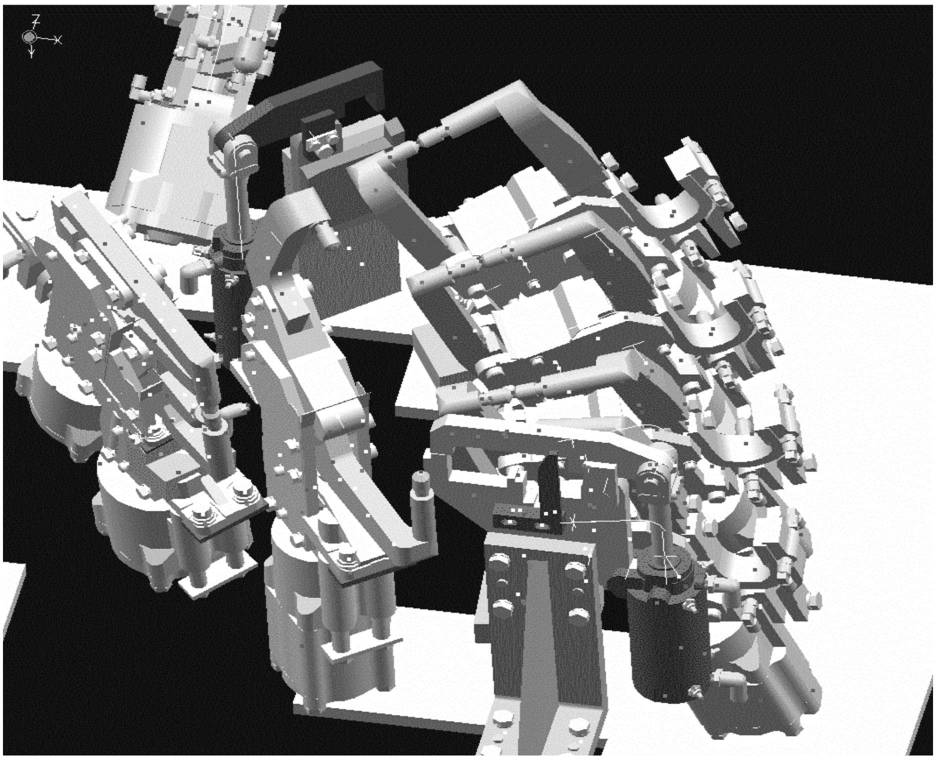

Figure 5-1 Example of welding equipment

5.3.4.2 User Description

5.3.4.2.1 Equipment Development Expectations for the Process Plan

The process plan data appears in the following five areas in Figure 5-2 tool development AAM.

- As output data from process design (A22) for mass production line
- As reference design specifications data for equipment details design (A23)
- As data that expresses the work procedure for equipment manufacturing (A24)
- As data that expresses the process procedure for mass production line
- As data for production control that generally expresses the process not limited to manufacture

Of these, the first four are within the AP214 application scope, but the process plan for production control is clearly outside the application scope of the AP214.

To put it differently, generally the following can be expected when handling process plan data using the AP214.

- For rationalization of mass production line process design (A22)
- For rationalization of equipment detail design (A23)
- For rationalization of equipment manufacture (A24)
- For rationalization of mass production process

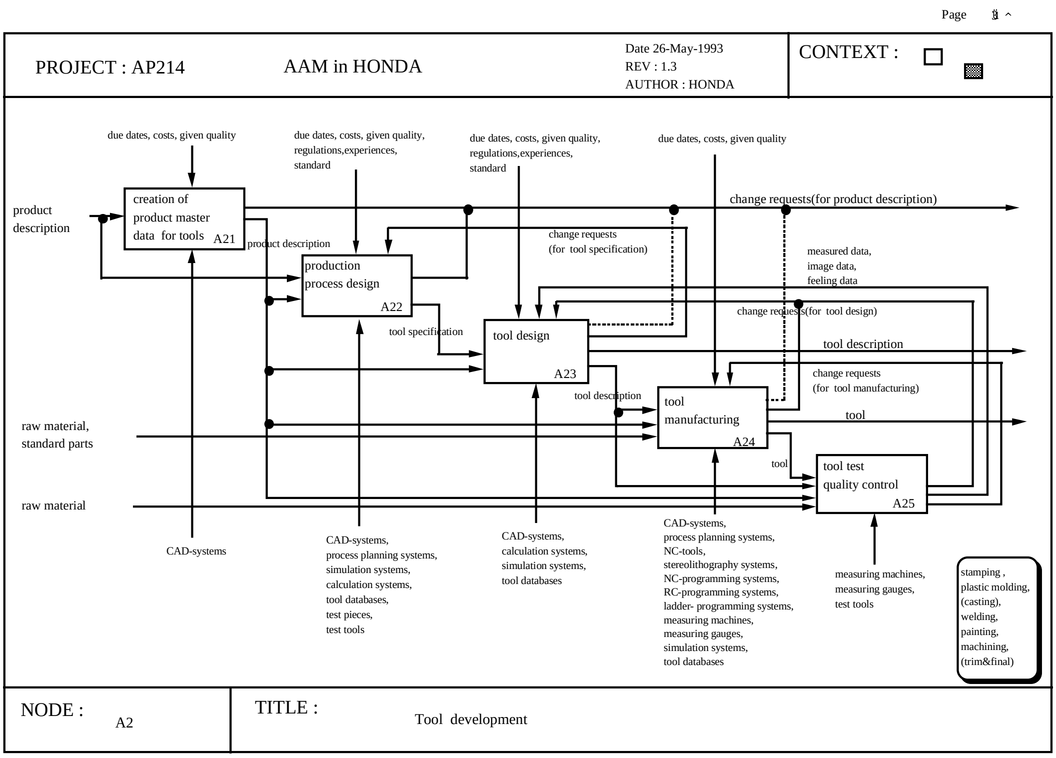

Figure 5-2 AAM of Tool development (A2)

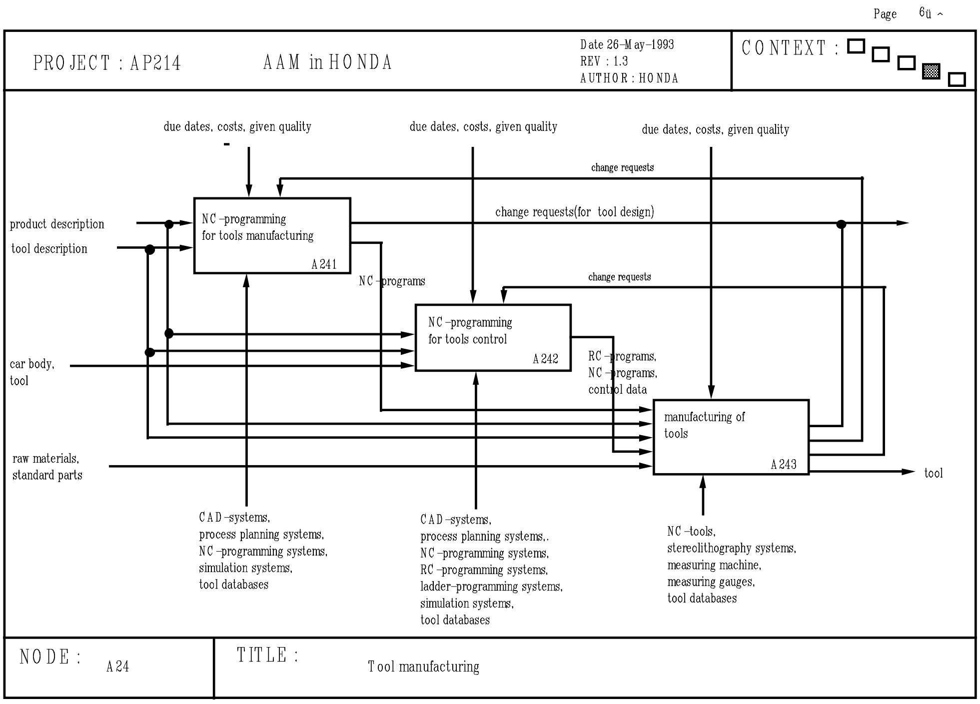

Figure 5-3 AAM of Tool manufacture (A24)

The main results that can be expected in production equipment development using data that centers on the process plan are listed below.

- For rationalization of the Production process design (A22)
  - Panel press process design
  - Body welding process design
  - Engine component machining process design
- For rationalization of tool design (A23) process
  - Press die design
  - Welding jig design
  - Engine component special machining equipment design
- For rationalization of NC-programming (A241) process
  - NC calculations for engine machining equipment manufacture
- For rationalization of NC-programming (A242) process
  - NC calculations for welding robot control
  - NC calculations for engine machining equipment control
- For rationalization of manufacturing of tools (A243) process
  - Manufacturing of press dies, injection molds, forging dies, and casting molds
- For rationalization of tool test and quality control (A25) process
  - Mass production welding line test
  - Mass production engine machining line test
  - Mass production assembly line test

Results are expected in a wide range of areas and processes for this kind of production equipment development.

5.3.4.2.2 I/O Data For All Equipment Development Processes

Figure 5-4 shows the input and output UoF for all equipment development processes.

Activity / UoF		production_process_design(A22)										NC-programing (A241) / NC-programing (A242)	
		stamping				welding		machining					
		stamping only		stamping & assembling				machining only		machining & assembly			
		input	output	input	output	input	output	input	output	input	output	input	output
S1	product_management_data	O	O	O	O	O	O	O	O	O	O	O	O
S2	element_structure	O	O	O	O	O	O	O	O	O	O	O	O
S3	item_definition_structure			O	O	O	O			O	O	O	O
S4	effectivity												
S5	work_management												
S6	classification												
S7	specification_control												
S8	process_plan		O		O		O		O		O		O
G1	wireframe_model_2D												
G2	wireframe_model_3D	O	O	O	O	O	O	O	O	O	O	O	O
G3	connected_surface_model	O	O	O	O	O	O	O	O	O	O	O	O
G4	faceted_b_rep_model												
G5	b_rep_model												
G6	compound_b_rep_model							O	O	O	O	O	O
G7	csg_model							O	O	O	O	O	O
G8	geo_bounded_surface_model												
MD1	measured_data												
PR1	item_property	O	O	O	O	O	O	O	O	O	O	O	O
P1	geometric_presentation												
P2	annotated_presentation												
P3	shaded_presentation												
D1	explicit_draughting												
D2	associative_draughting	O	O	O	O	O	O	O	O	O	O	O	O
K1	kinematics												
FF1	user_defined_feature	O	O		O	O	O	O	O	O	O	O	O
FF2	included_feature	O	O		O	O	O	O	O	O	O	O	O
FF3	generative_featured_shape	O	O		O	O	O	O	O	O	O	O	O
C1	surface_conditions							O		O		O	
T1	dimension_tolerances							O		O		O	
T2	geometric_tolerances							O		O		O	
E1	external_reference_mechan.	O	O	O	O	O	O	O	O	O	O	O	O

Figure 5-4 UoF of Input/Output

5.3.4.2.3 Items Subject To The Study

Because the subject items in the process design have very different characteristics, study subjects with very different characteristics were also selected.

The range of the study subjects and specific examples are given below. (Refer to Figure 5-5.)

- For press form processing design:
  - Side outer panel (when one part is formed)
  - Door panel (when multiple parts are formed at the same time)
  - Roof panel (alternate forming of multiple parts)
  - Door component (when formed and assembled at the same time)
- For press die mannufacturing process design
  - Press die for forming side outer panel
- For engine processing process design
  - Engine cylinder block
- For welding process design
  - Side panel components (when spot welding)

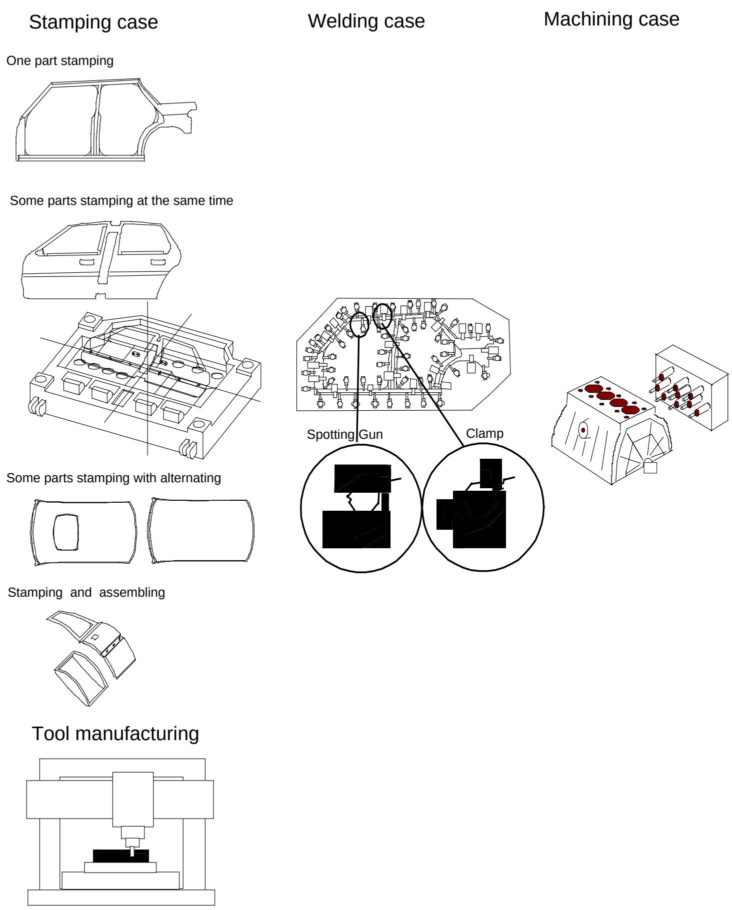

Figure 5-5 Overview of subject study items

5.3.4.2.4 Study Items

For this project, we studied the detailed design for press dies, welding equipment, and engine part processing equipment to identify the following.

- What data is required for reference design specifications?
- Can this information be expressed without contradiction using mainly the next UoF of the AP214?
  - Process plan (S8)
  - Form feature (FF1, FF2, FF3)
  - Assembly relation (S3)

5.3.4.3 Mapping to the AP214's ARM

5.3.4.3.1 Reference Structure Portion Around the Process Plan

5.3.4.3.1.1 Relationship Between The Process Plan layered Structure and Equipment Assembly Structure

The process design unit depends on the company and operation.

For the mass production engine machine line process design, the process design unit is the entire machine processing of one engine component (for example, the engine cylinder block).

The process plan is configured using the process data from the layered structure.

For the machining line process design, this is the process data corresponding to the order from one top level, for example process system level, cycle time level, process device level, compound process level, or minimum element process level. (Refer to the left half of Figure 5-6.)

Next the mass production equipment detailed design is created based on the process plan data that the various equipment is designed in accordance with the corresponding process data which results in a model that corresponds to the process layered structure and equipment assembly structure as shown in Figure 5-6.

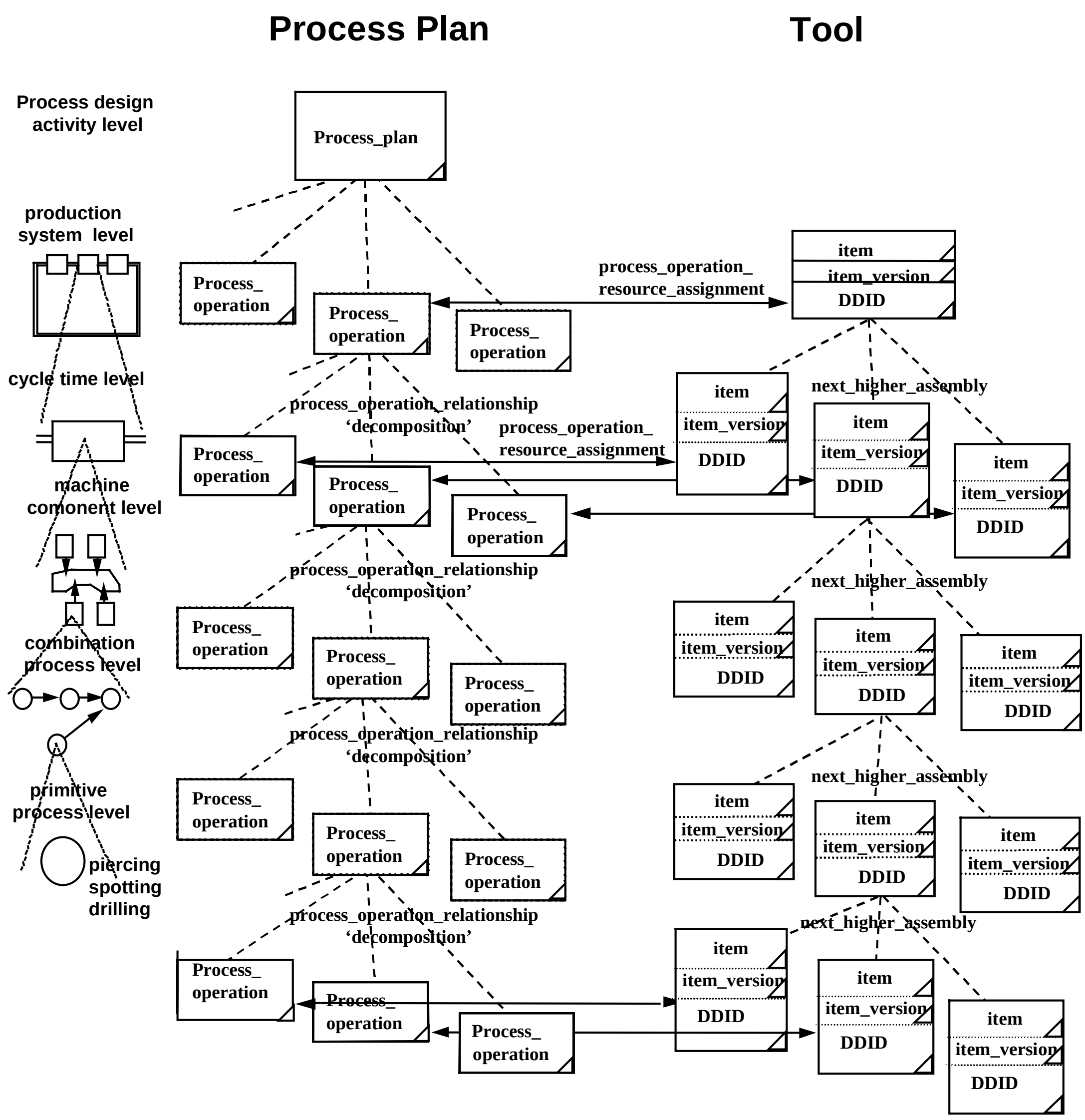

Figure 5-6 Process plan layered structure and equipment assembly structure

5.3.4.3.1.2 Process Plan Version Expression

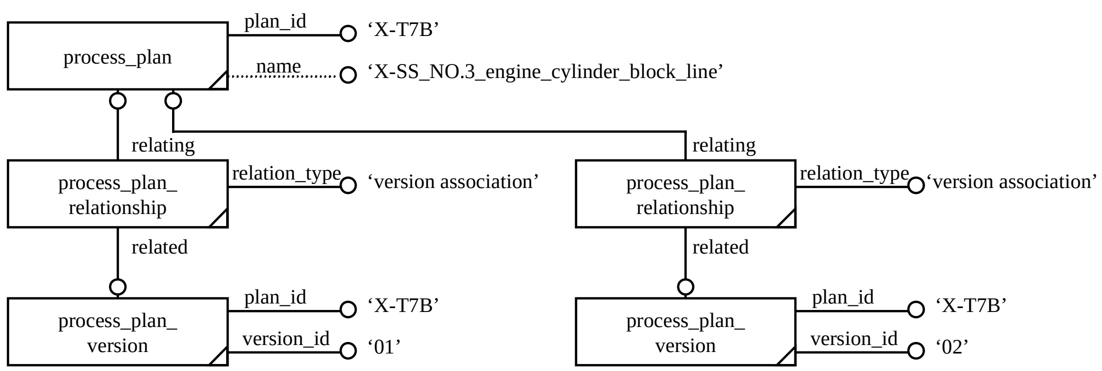

Figure 5-7 Instance of process plan version expression

5.3.4.3.1.3 Process Plan and Process Attribute Expression

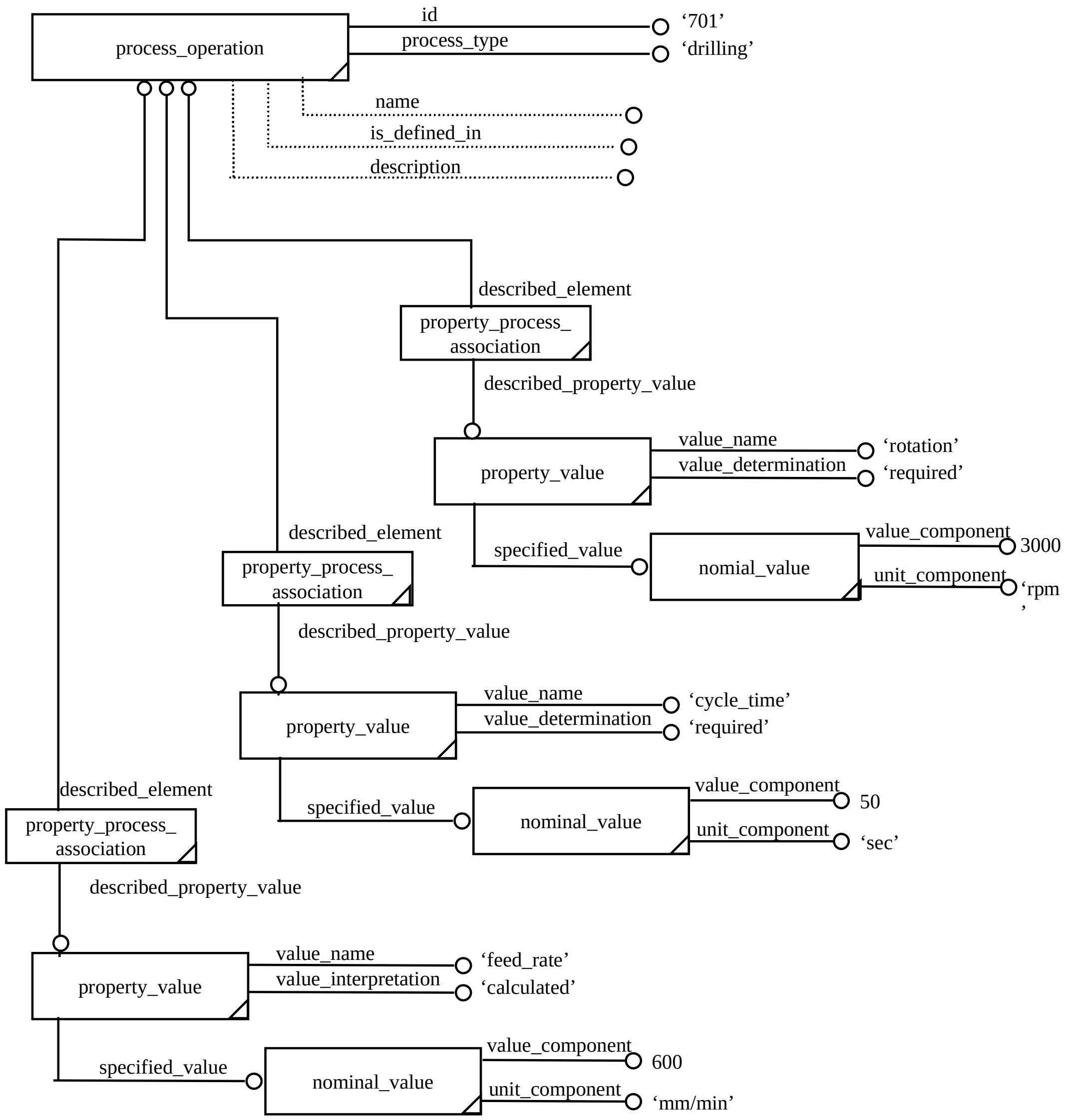

Figure 5-8 Instance of process attribute

5.3.4.3.1.4 Relationship Between Process Plan and the Organization

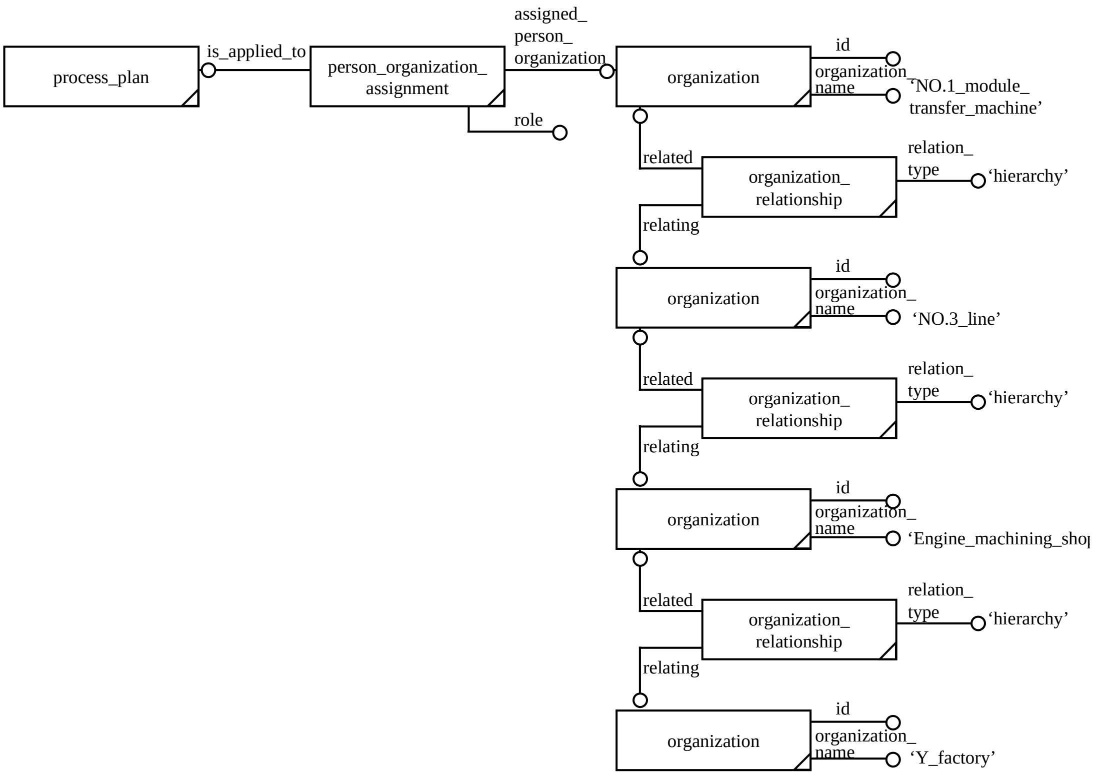

Figure 5-9 Instance of relationship with organization

5.3.4.3.2 For Stamping Process Design

5.3.4.3.2.1 Side Outer Panel Press Process

The press process generally includes blanking, drawing, trimming and bending processes, through which a final panel is obtained.

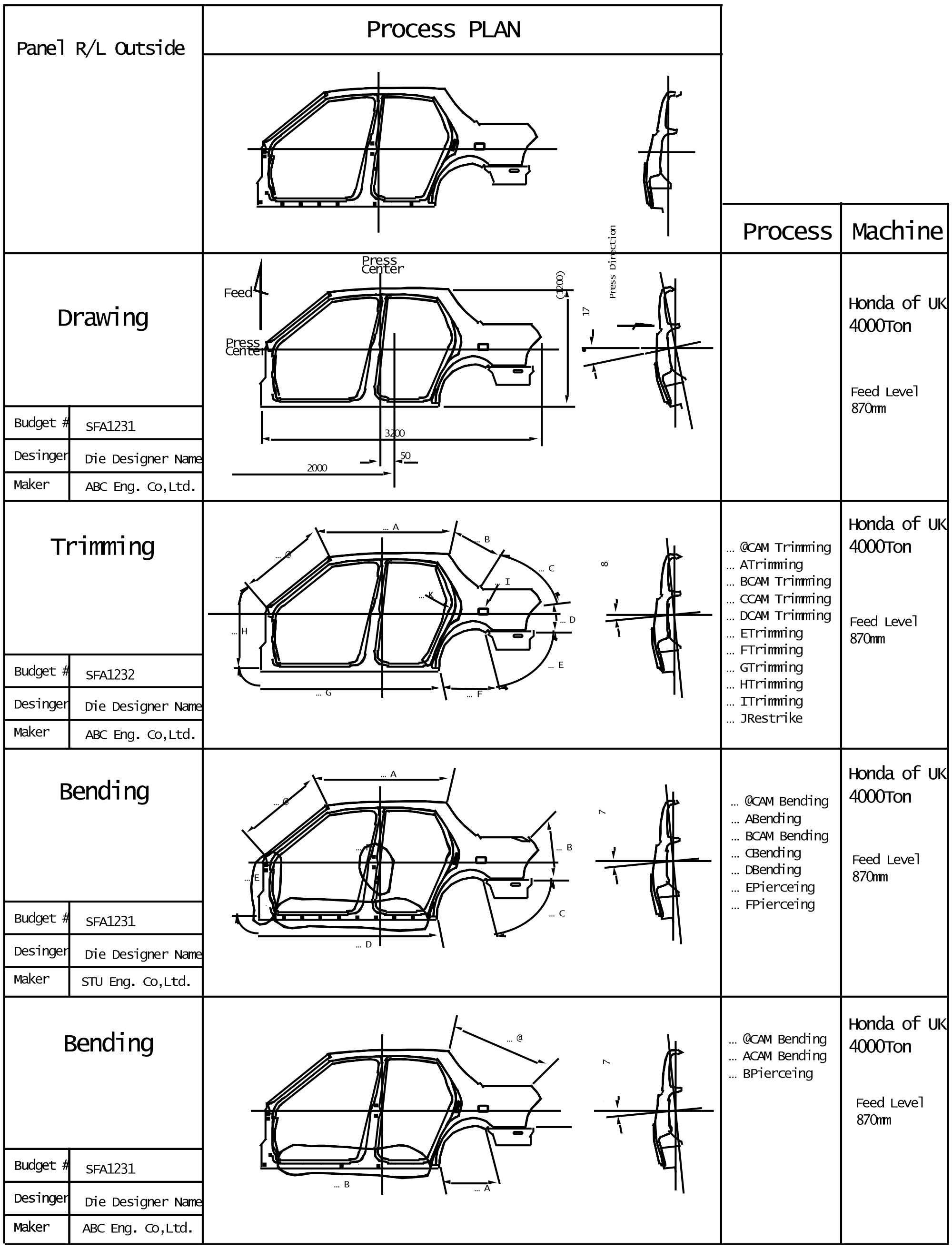

Figure 5-10 Side outer panel form process design results (for drawing expression)

Figure 5-11 below shows an overview of products, process plans, and die instances.
The left, middle and right streams vertically separated represent products, process plans, and dies, respectively, which are individually extracted and enlarged in Figure 5-12 to Figure 5-17.
Products are shown in Figure 5-12 and Figure 5-13, process plans at parent process level in Figure 5-14, process plans at child process level in Figure 5-15, and dies in Figure 5-16 and Figure 5-17.
Figure 5-12 corresponds to AREA A in Figure 5-11, Figure 5-13 corresponds to AREA B in

Figure 5-11, Figure 5-14 corresponds to AREA C in Figure 5-11, Figure 5-15 corresponds to AREA D in Figure 5-11, Figure 5-16 corresponds to AREA E in Figure 5-11, Figure 5-17 corresponds to AREA F in Figure 5-11.

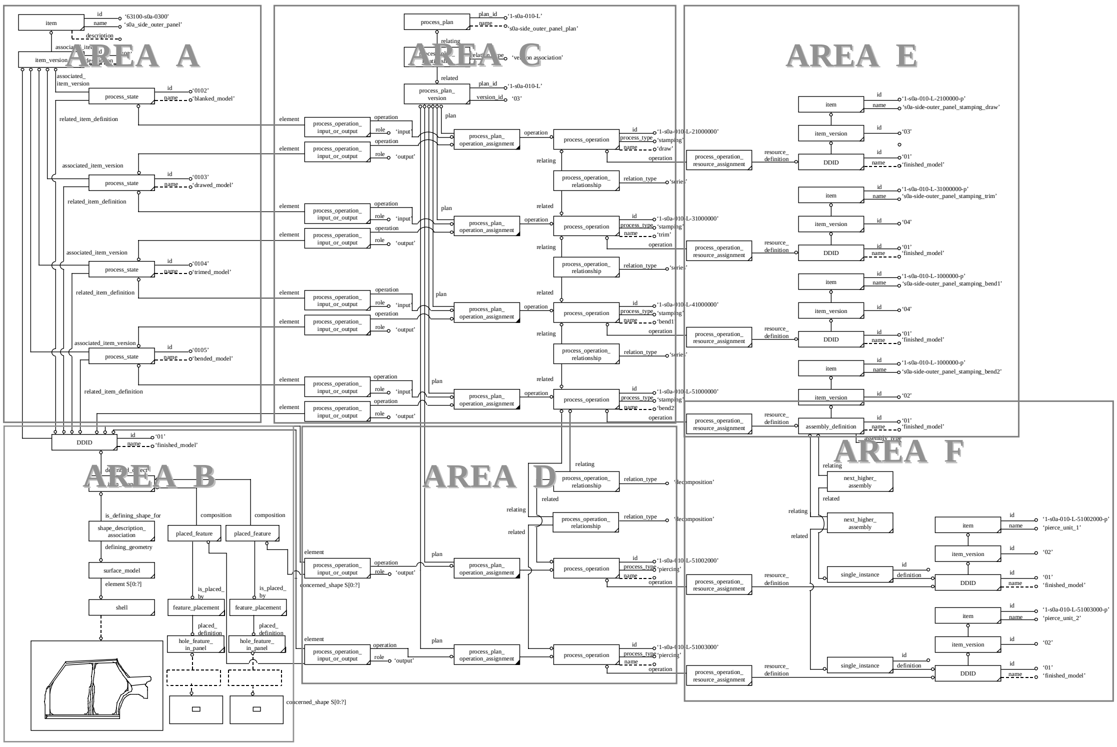

Figure 5-11 Overview of instance of products, process plans, and die instances (side outer panel)

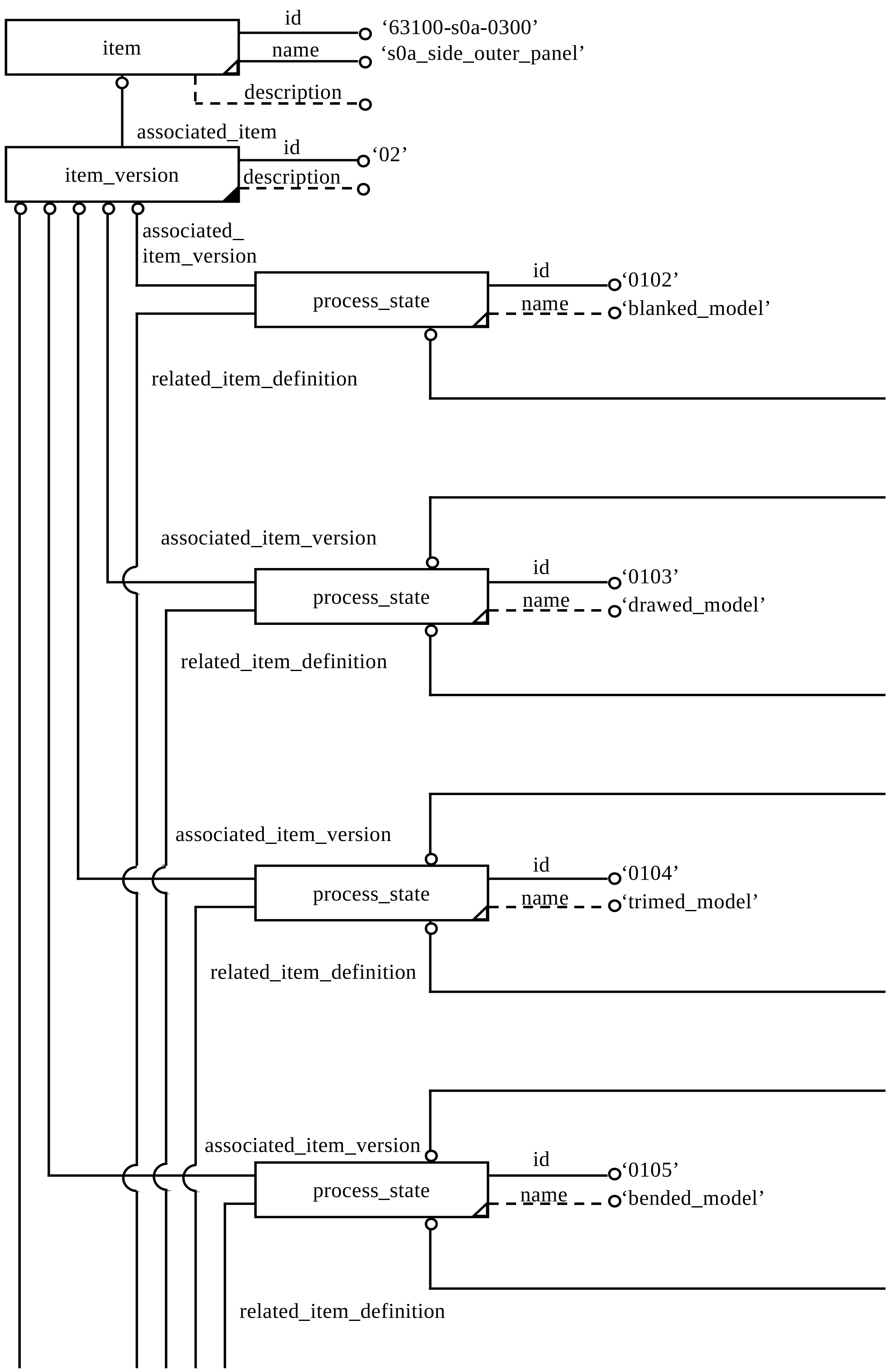

Figure 5-12 Representation of product forming process (side outer panel)

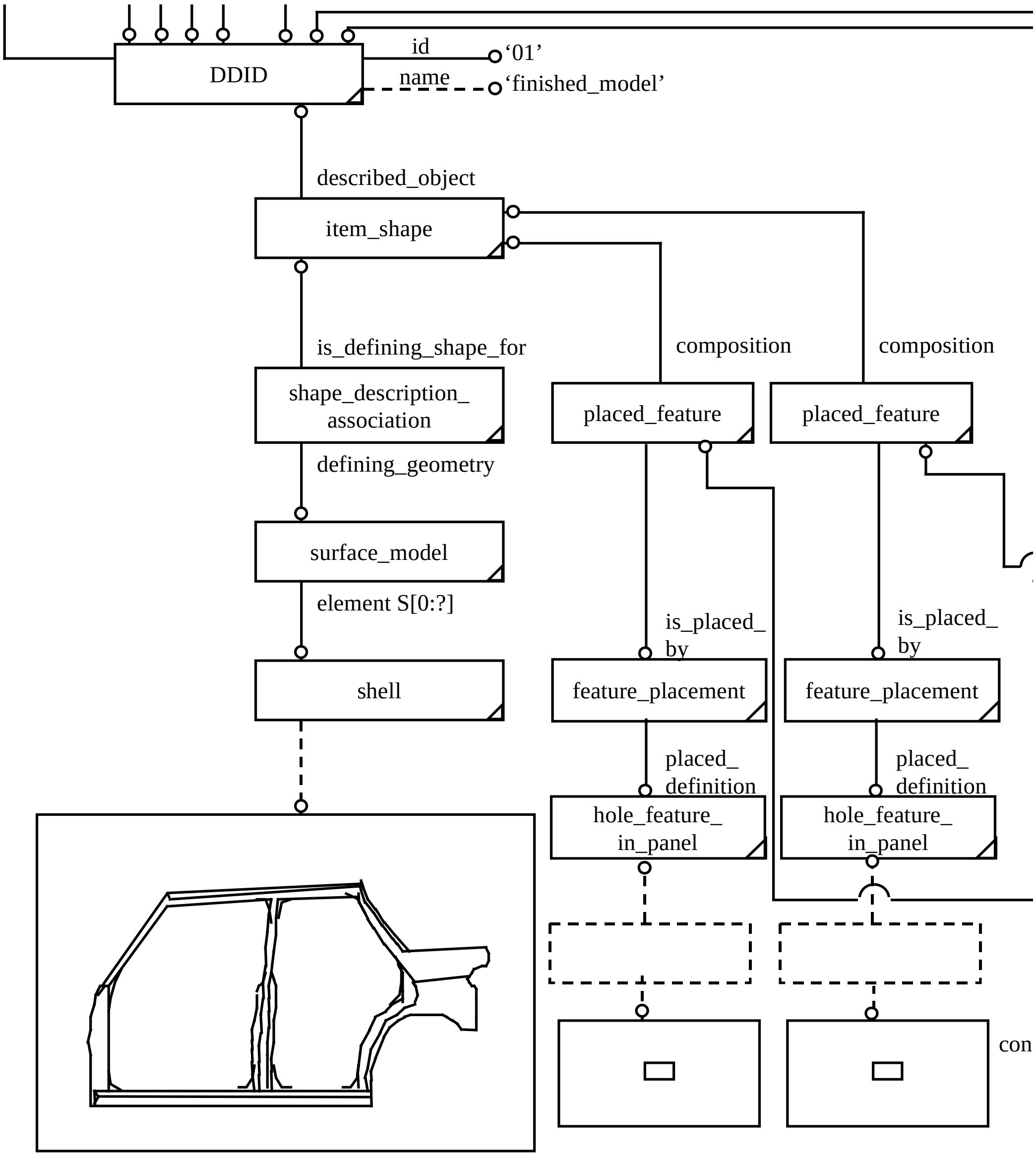

Figure 5-13 Representation of product shapes including form features (side outer panel)

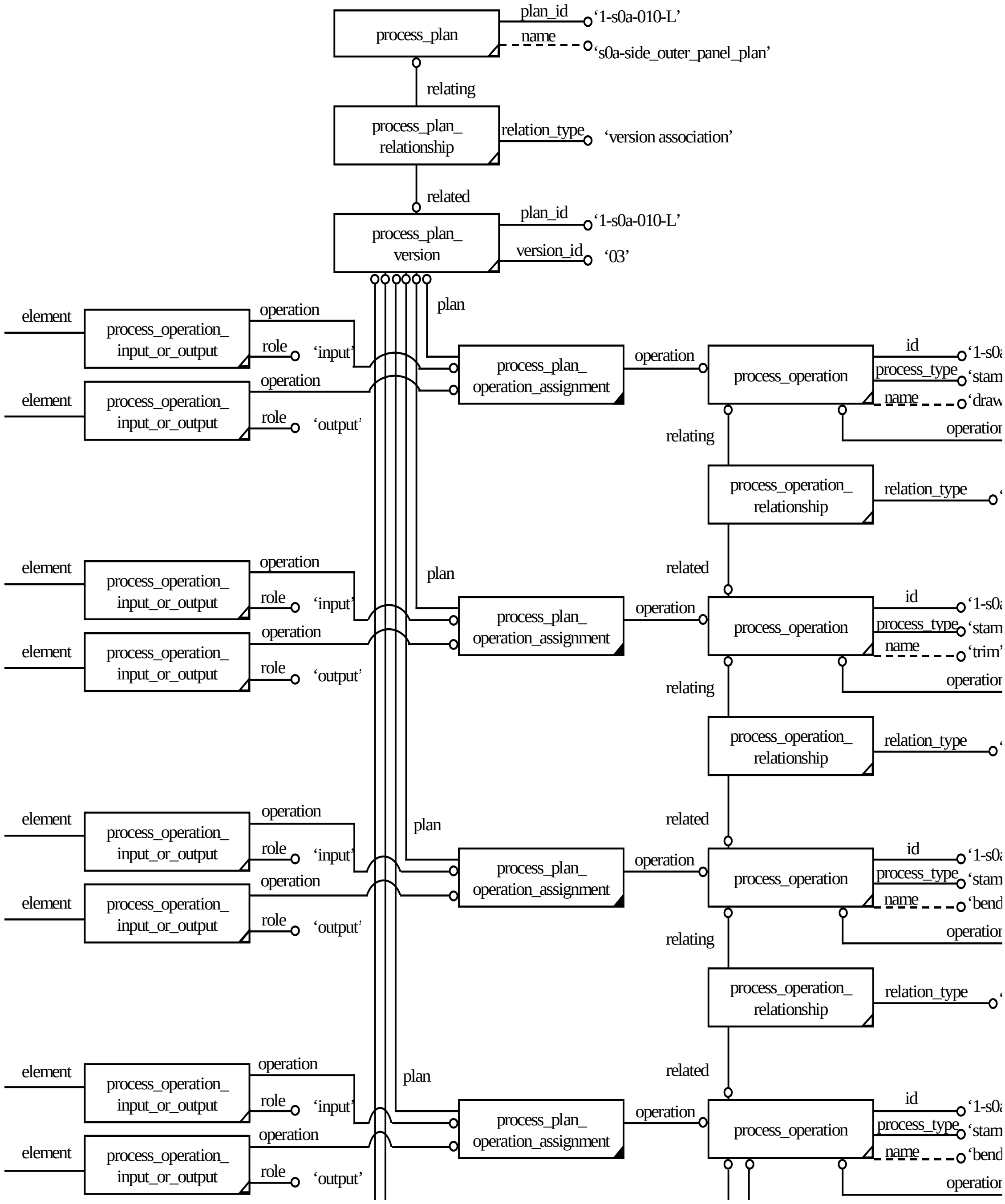

Figure 5-14 Process plans at parent process level (side outer panel)

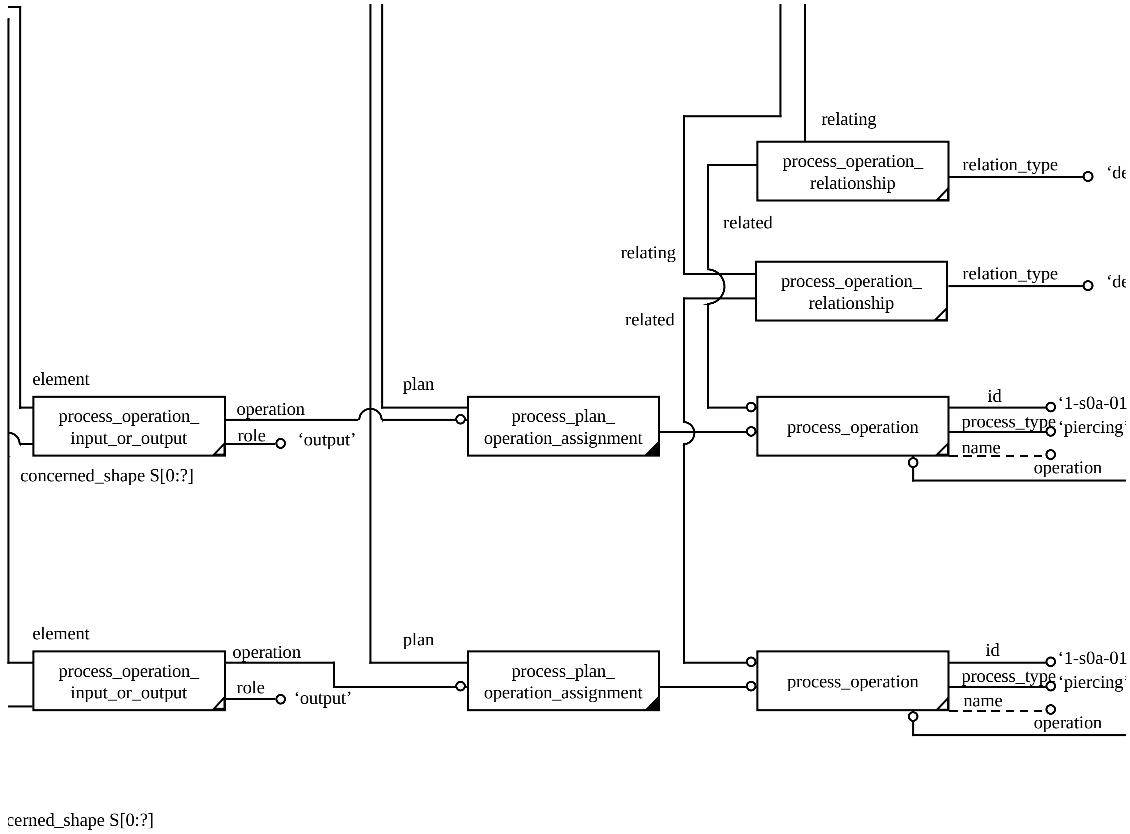

Figure 5-15 Process plans at child process level (side outer panel)

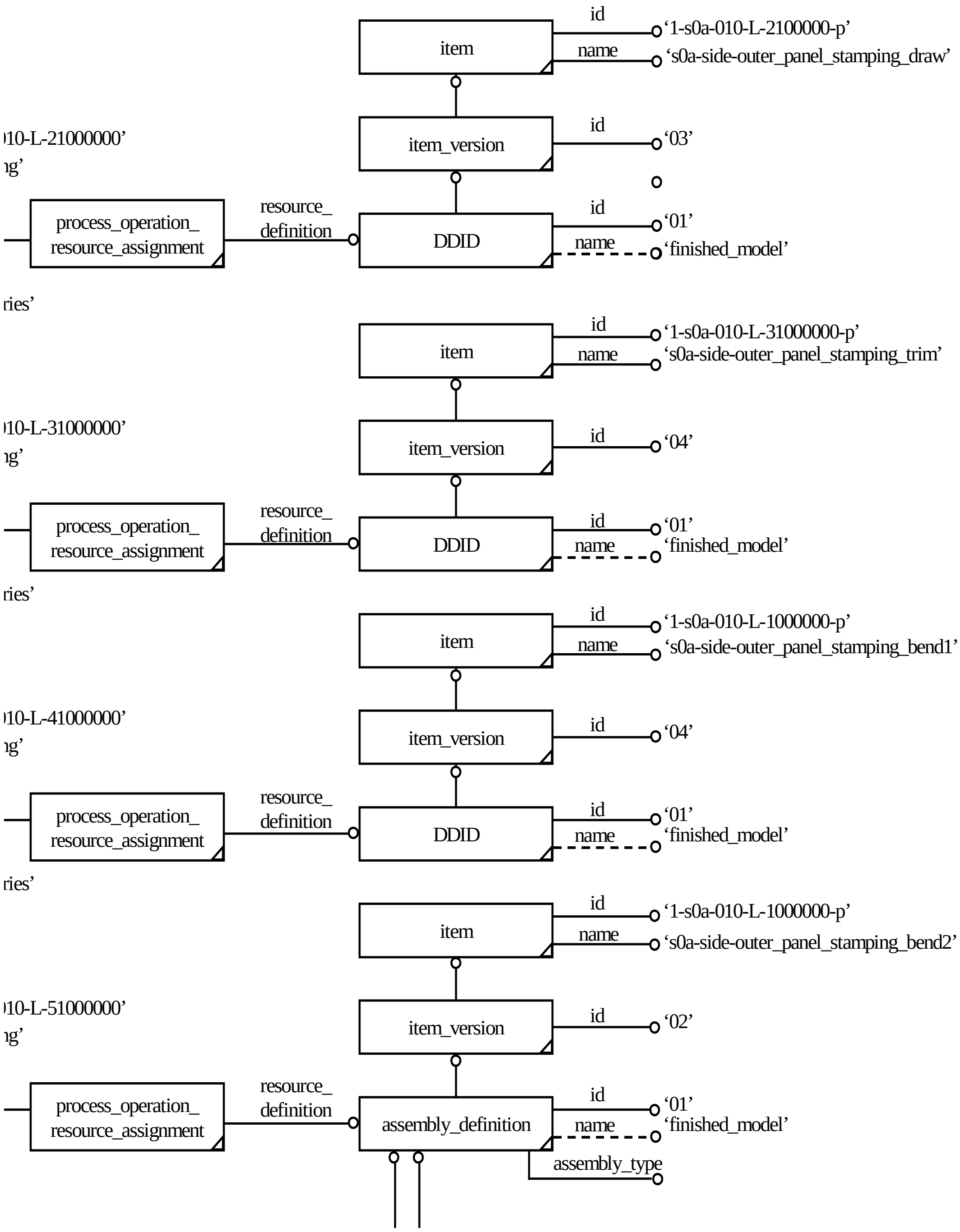

Figure 5-16 Process plans and die at parent process level (side outer panel)

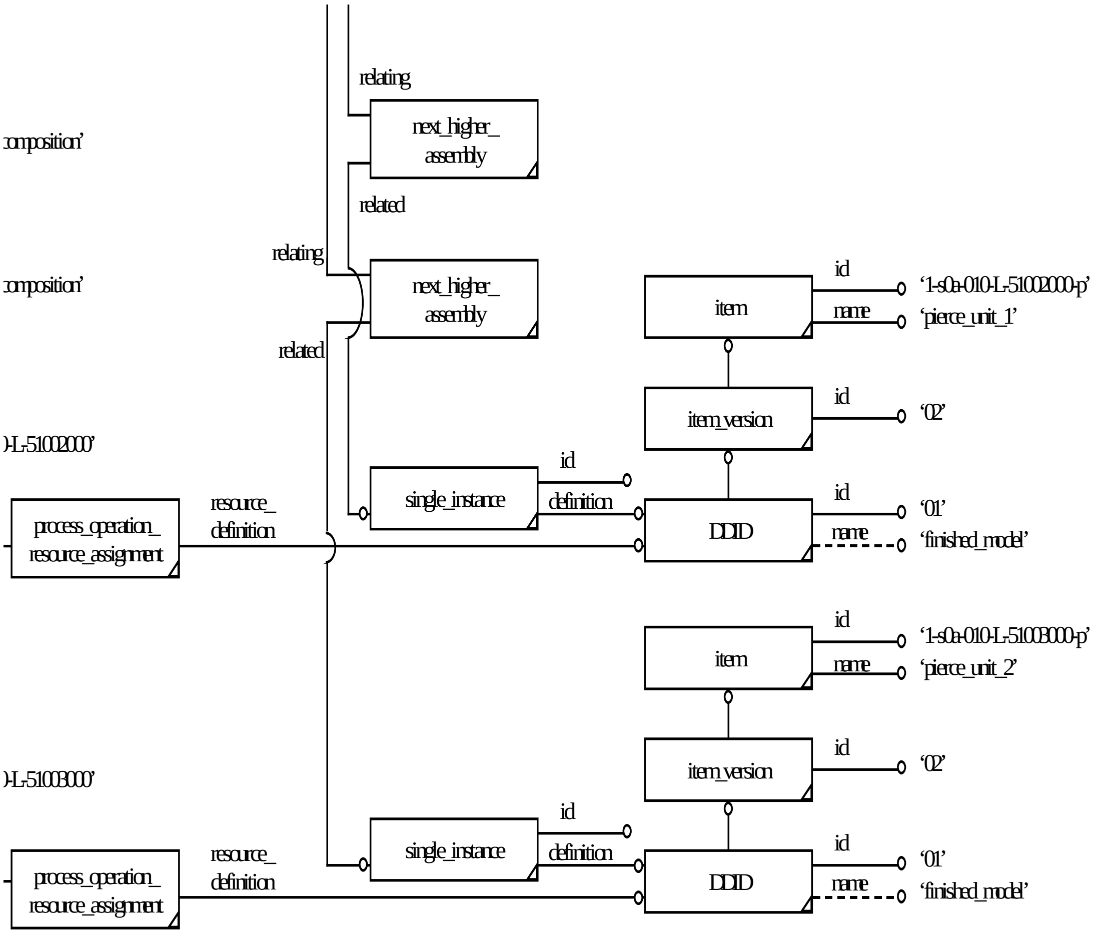

Figure 5-17 Process plans and die assembly at child process level (side outer panel)

5.3.4.3.2.2 Door Outer Panel Press Process

Figure 5-18 below shows an overview of products which name is ‘Door outer Panel’, process plans, and die instances.

Products are shown in AREA A in Figure 5-18, detail are shown in Figure 5-19.

Process plan at parent process level are shown in AREA B in Figure 5-18, detail are shown in Figure 5-20.

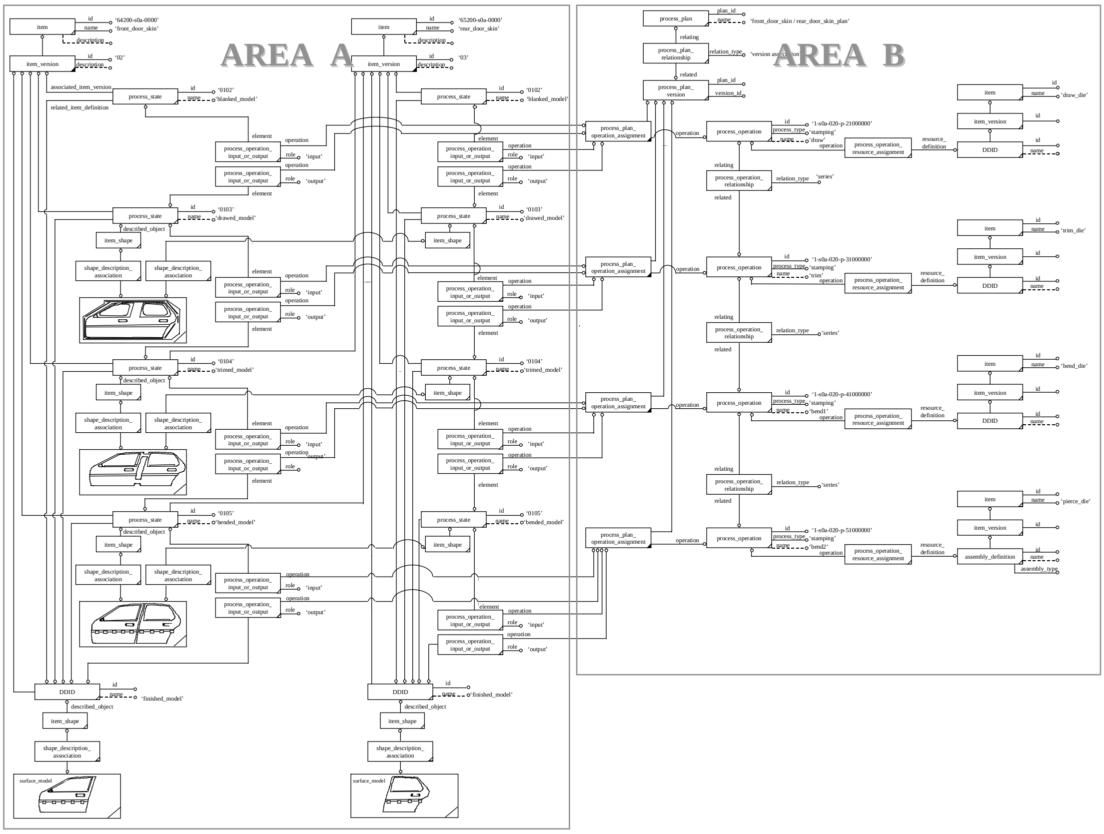

Figure 5-18 Overview of products, process plans, and equipment instances (door outer panel)

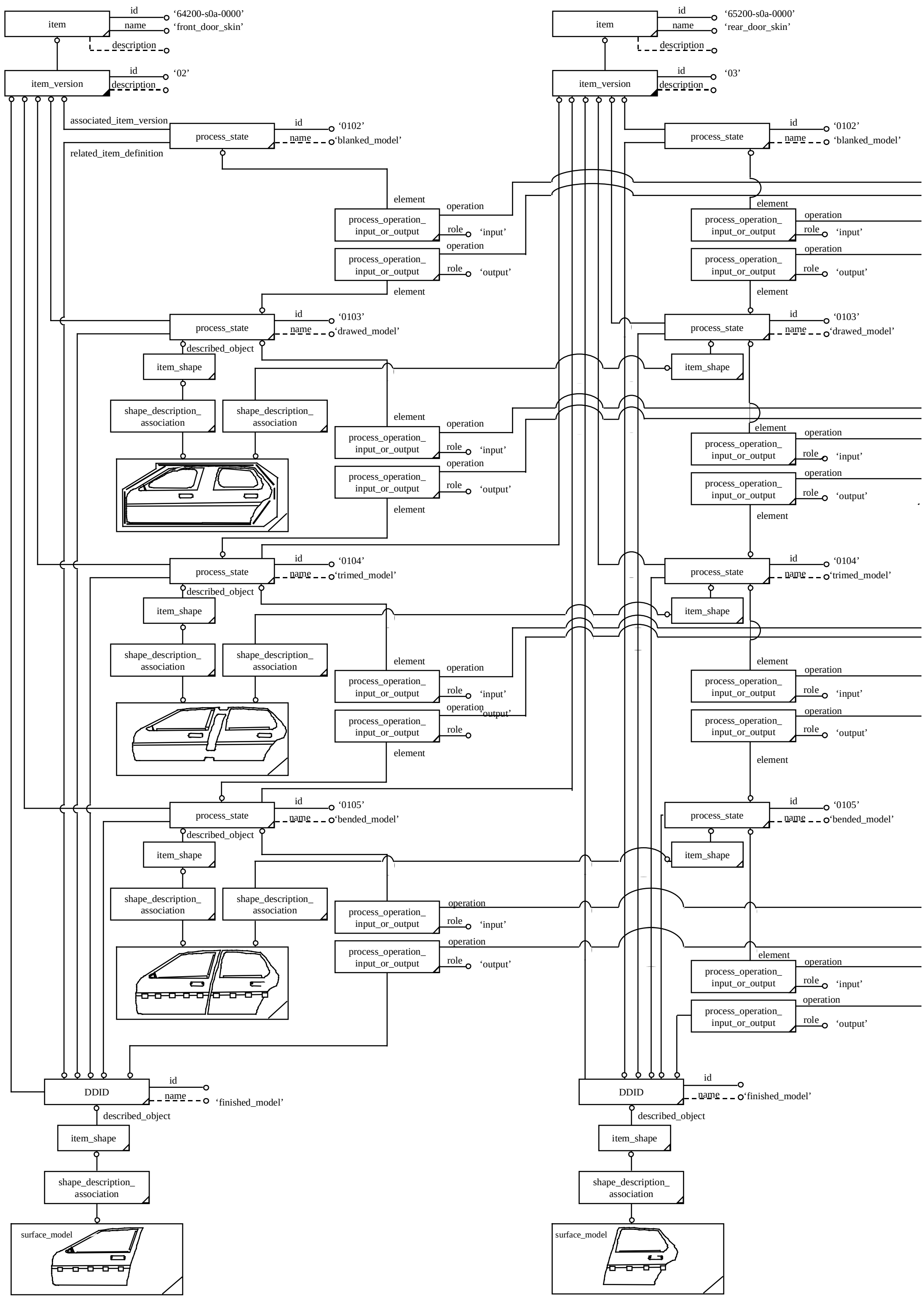

Figure 5-19 Representation of product forming process (door outer panel)

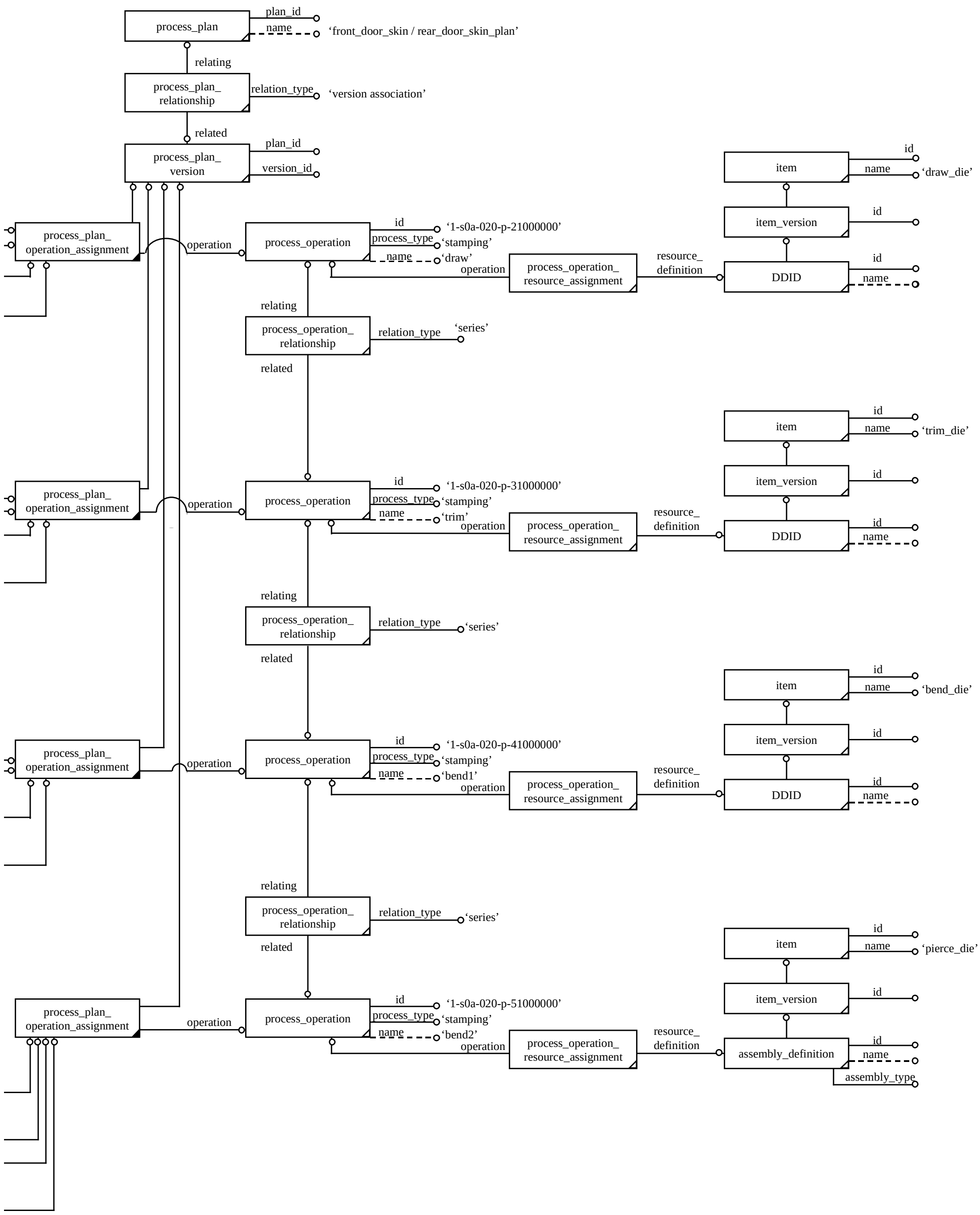

Figure 5-20 Process plans at parent process level (door outer panel)

5.3.4.3.2.3 Roof Panel Press Process

Figure 5-21 below shows an overview of products which name is 'Roof Panel', process plans, and die instances.

Products are shown in AREA A in Figure 5-21, detail are shown in Figure 5-22.

Process plan at parent process level are shown in AREA B in Figure 5-21, detail are shown in Figure 5-23

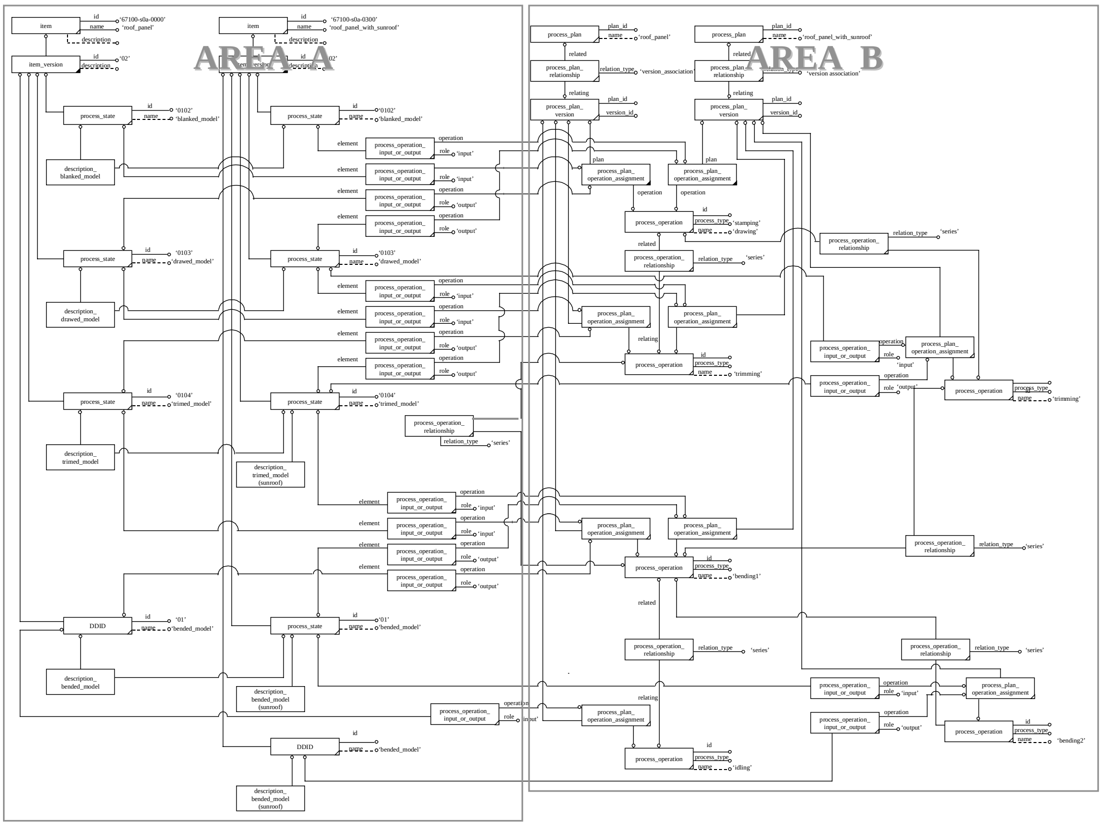

Figure 5-21 Overview of product and process plan instance (roof panel)

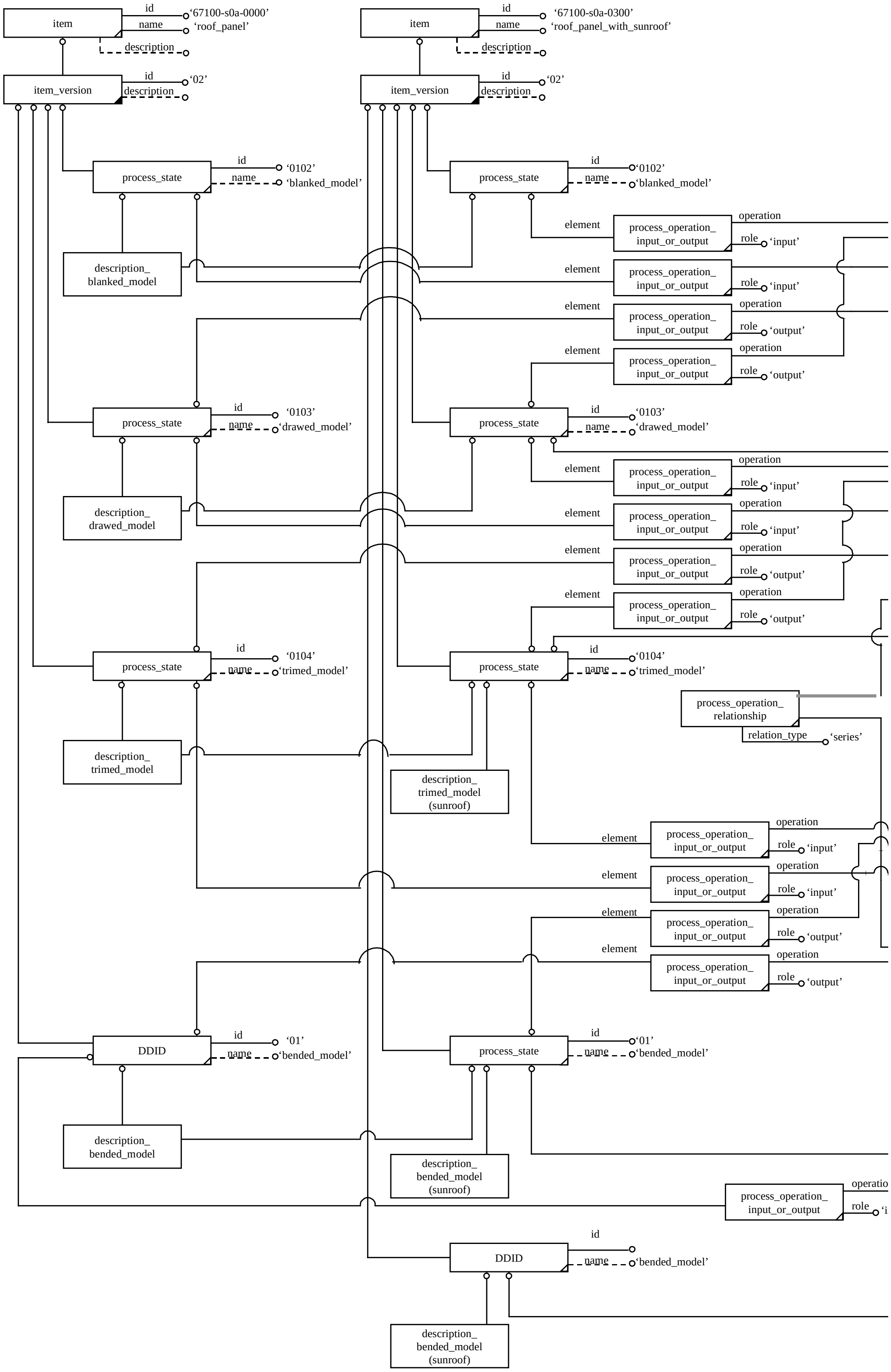

Figure 5-22 Representation of product forming process (roof panel)

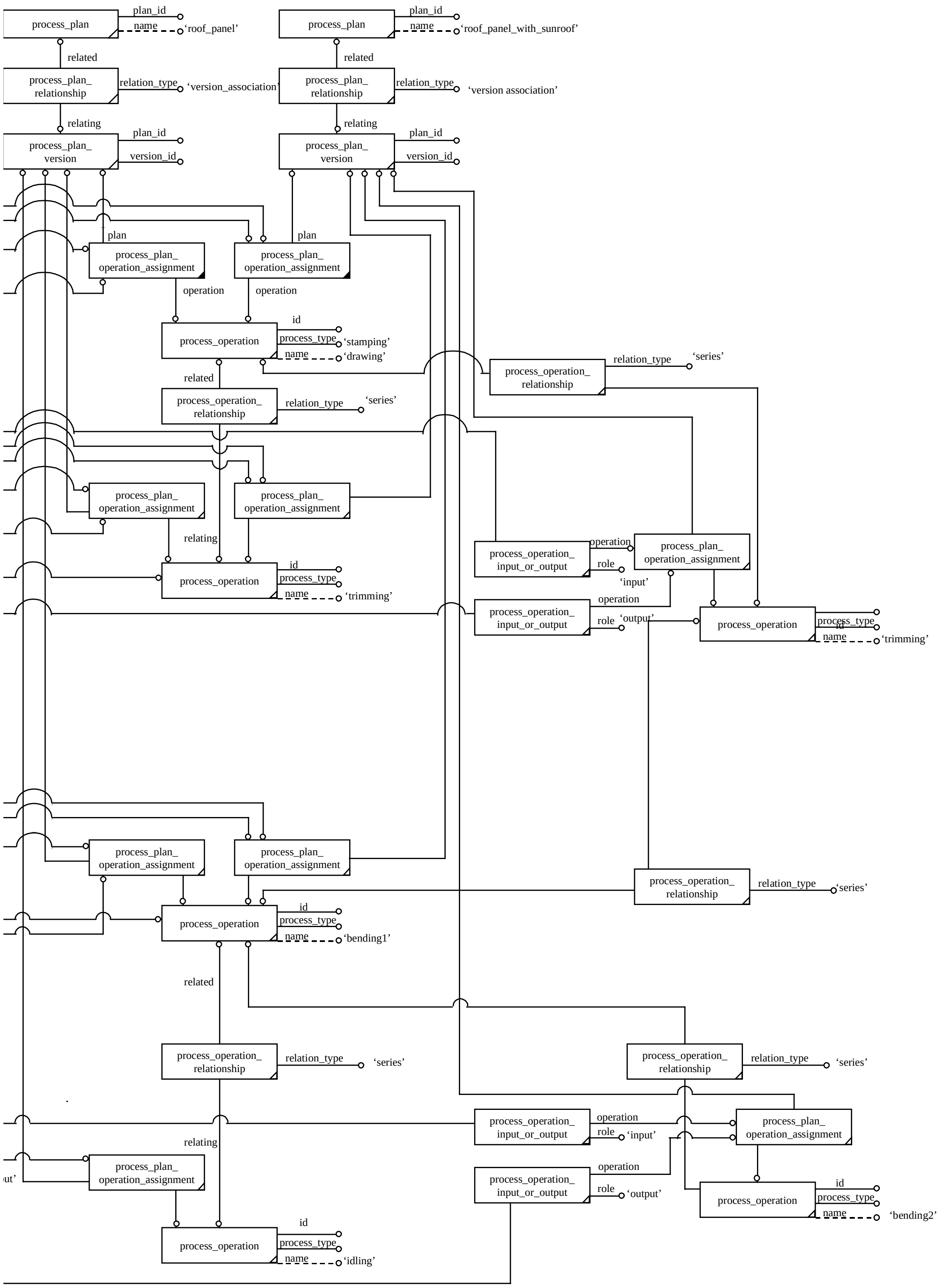

Figure 5-23 Process plans at parent process level (roof panel)

5.3.4.3.2.4 Door Components Press Processing

The door components press processing conducts assembly while press forming the door outer panel and door inner panel, so it can be expressed as a combination of pure press processing (Refer to Item 5.3.4.3.2.1) and pure assembly processing (Refer to Item 5.3.4.3.4.1).

5.3.4.3.3 For Machining Process Design

5.3.4.3.3.1 Engine Cylinder Block Processing Process

	Item		Description				Amendments
1	Subject equipment	Line name Equipment name	Y SS NO.3 BLOCK LINE NO.1 MO TR M/C				
2	Subject work		Current conditions		Conditions after installation		
		Model	P13(L4) PV1(L52.5L) PV0(L52.0L)		P13(L4) PV1(L52.5L) PV0(L52.0L) PY3(V63.2L) P5A(V63.5L)		
		Product name	CYL.BLOCK		CYL.BLOCK		
3	Process description	Machining area Machining type	OP,DP,FACE Milling, channeling, channel width determination D.R.Z.T		OP,DP,FACE Milling, channeling, quality width determination, quality back escape, oil channel M, D, R, Z, T		
4	Machining quality	Control method Control width	Within product's drawing tolerance		Refer to the attachment		
5	Production capability	Cycle time	L4: __ sec L5: __ sec	Monthly production __ units/S Operation rate __%	L4: __ sec L5: __ sec V6: __ sec	Monthly production __ units/S Operation rate __%	
6	Model handling	Number of models	3		5		
		Equipment change method	Automatic		Automatic		
		Equipment change conditions	10 minutes/day		10 minutes/day		
7	Construction range	Special section	- Palette - G/H - Insert and removal R/B finger - Holder for NN-II - Angle head - NC PRG		11 palettes 13G/H 2 machines 1 unit 1 machine 2 sets		
		General section	- 6 INDEX MO M/C added to 8BST - TV JIG BASE added to 8BST - Return C/V extension - First portion link unit extension - Palette stacker made to three levels - Work insertion and removal C/V modification - Finger stacker modification				
8	Local	Construction					

Figure 5-24 Required specifications for process design
(Engine cylinder block)

	SP. No.	Class	2ST-B NN-II	3ST-B NN-II	4ST-B 6INDEX-Mo 4 G/H	5 G/H	6 G/H	5ST-B 6INDEX-Mo 5 G/H	6 G/H	6ST-B 6INDEX-Mo 4 G/H	5 G/H	6 G/H	(4 G/H)	7ST-B 6INDEX-M 5 G/H	6 G/H	8ST-B 6INDEX-M 4 G/H	5 G/H
	701	O			DD	D			R(O-H)	K	RC	T	K				
	702	O			DD	D			R(O-H)	K	RC	T	K				
	703	O			DD	D			R(O-H)	K	RC	T	K				
	704	O			DD	D			R(O-H)	K	RC	T	K				
	705	O			DD	D			R(O-H)	K	RC	T	K				
	706	O			DD	D			R(O-H)	K	RC	T	K				
	707	O			DD	D			R(O-H)	K	RC	T	K				
	708	O			DD	D			R(O-H)	K	RC	T	K				
	709	O					DC	D		K			(K)	R	T		
	710	O					DC	D		K			(K)	R	T		
	711	O					DC	D		K			(K)	R	T		
	712	O					DC	D		K			(K)	R	T		
	713	O					DC	D		K			(K)	R	T		
	714	O					DC	D		K			(K)	R	T		
	715	O					DC	D		K			(K)	R	T		
	716	O					DC	D		K			(K)	R	T		
	717	O					D	D		K			(K)				
	718	O					D	D		K			(K)				
	719	O					D	D		K			(K)				
	721	O			D					K			(K)		T		
	722	O	Milling														
	723	O	Milling														
	724	O		Width determination													
	725	O			D	D		D		K			(K)				
	726	O			D	D		D		K			(K)				
	727	O			D	D		D		K			(K)				
X	728	O			D	D		D		K			(K)				
	729	O					D			K	RC		K				
	730	O					D			K	RC		K				
	731	O				D				K	RC	T	K				
	732	O			D					K		T	K				
	733	O				D				K	RC	T	K				
	734	O			D					K		T	K				
J	735	O			D					K		T	K				
	736	O			D					K		T	K				
	737	O			D					K		T	K				
	738	O			D					K		T	K				
	739	O				D				K			(K)		T		
	740	O			D					K		T	K				
	741	O			D					K			(K)		T		
	742	O			D					K		T	K				
	743	O			D					K		T	K				
	744	O					D	D(CH)		K			(K)		T		
	745	O					D	D(CH)		K			(K)		T		
	747	O															OILRM
	748	O															OILRM
	749	O															OILRM
	750	O															OILRM
	751	O												Metal notching			
	752	O												Metal notching			
	753	O												Metal notching			
	754	O												Metal notching			
	756	O														Weight M	
	757	O														Weight M	
	758	O														Weight M	
	759	O														Weight M	
	761	O							DZ	K	RC		K				
	762	O							DZ	K	RC		K				
	763	O							D	K			(K)				
	764	X														D	
	765	X														Thrust M	
	766	X														Weight M	

Figure 5-25 Part of the process design results drawing (Engine cylinder block)

The engine cylinder block process design includes the machining process, inspection process, and assembly process for the engine cylinder block from the material to completion.

Some of the results from this are shown in Figure 5-25.

In Figure 5-25 the SP No. shows the element subject to processing on the vertical axis and the mass-production processing station on the horizontal axis.

In addition, D stands for drill processing, R for reamer processing, T for tap processing, and K for inspection.

Figure 5-26 below shows an overview of products which name is ‘Engine cylinder block’, process plans, and die instances.

Products are shown in AREA A in Figure 5-26, detail are shown in Figure 5-27.

Process plan at parent process level are shown in AREA B in Figure 5-26, detail are shown in Figure 5-28.

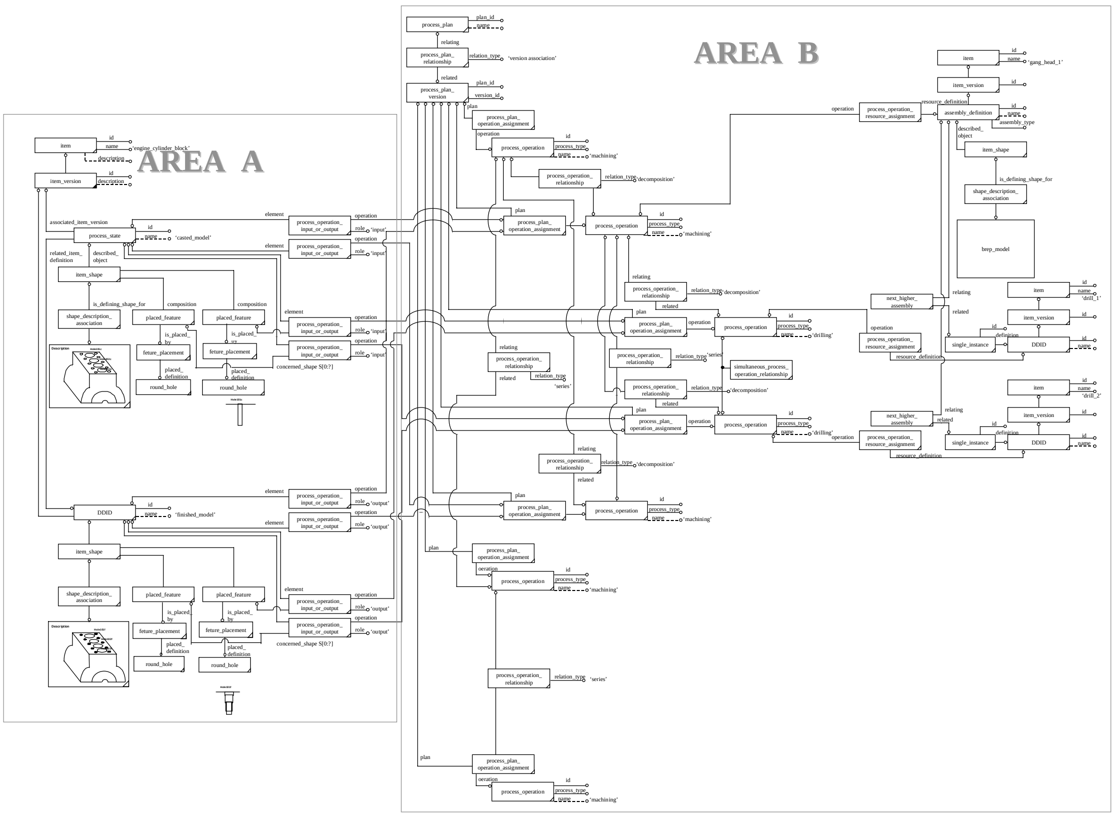

Figure 5-26 Overview of products and process line instances (Engine cylinder block)

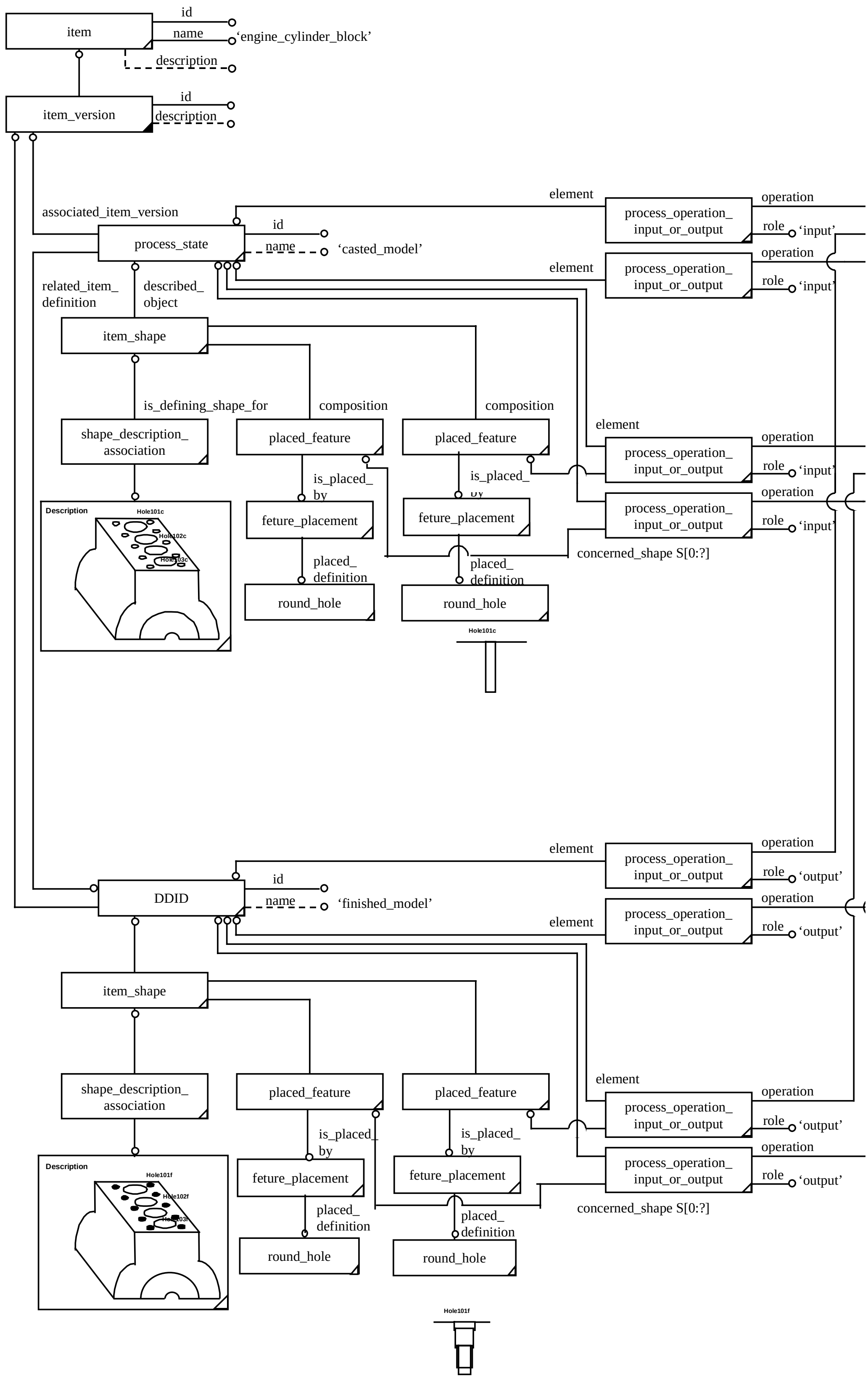

Figure 5-27 Representation of materials and final products (Engine cylinder block)

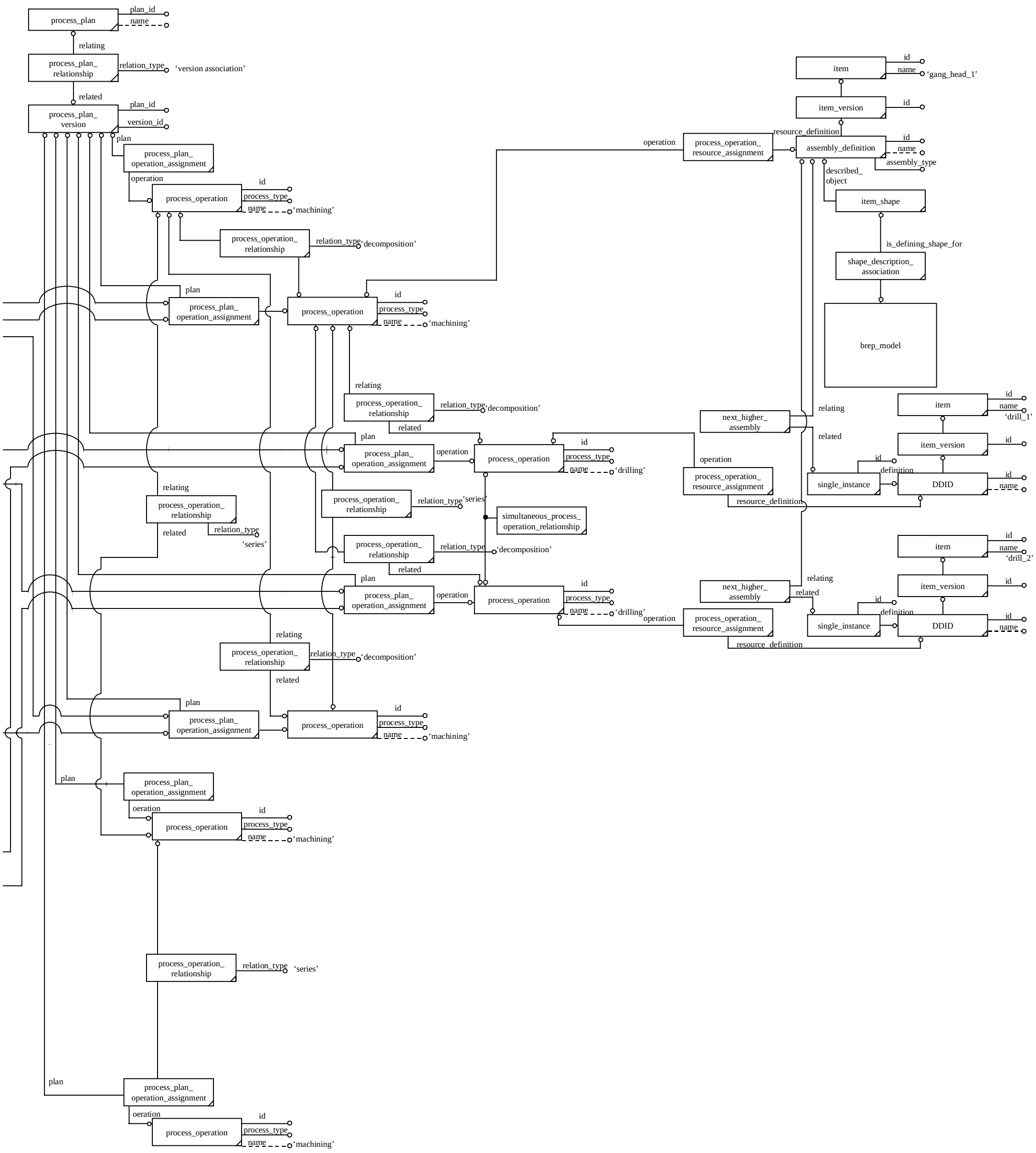

Figure 5-28 Process plans (Engine cylinder block)

Included in the processing of engine cylinder block are assembly and disassembly as shown in Figure 5-29, which can also be represented (Refer to 5.3.4.3.4.1).

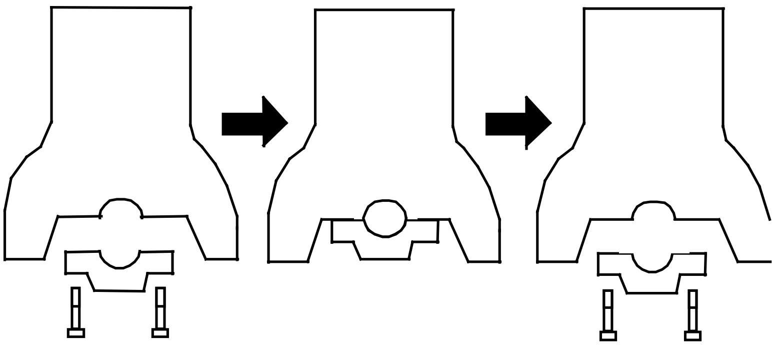

Figure 5-29 Example of process including assembly and disassembly

5.3.4.3.4 For Welding Process Design

5.3.4.3.4.1 Body Component Welding Process

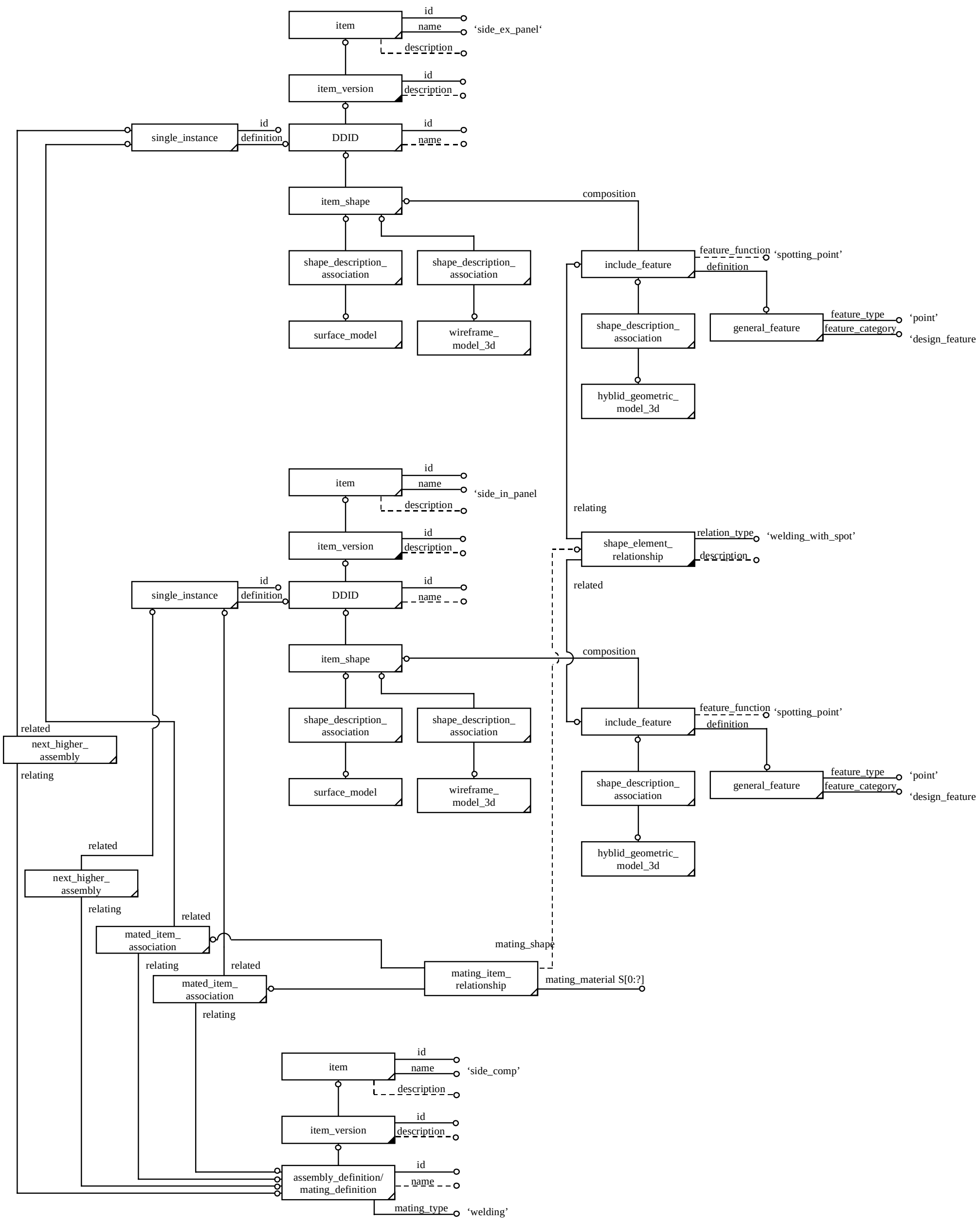

Figure 5-30 Representation of panels assembled by welding

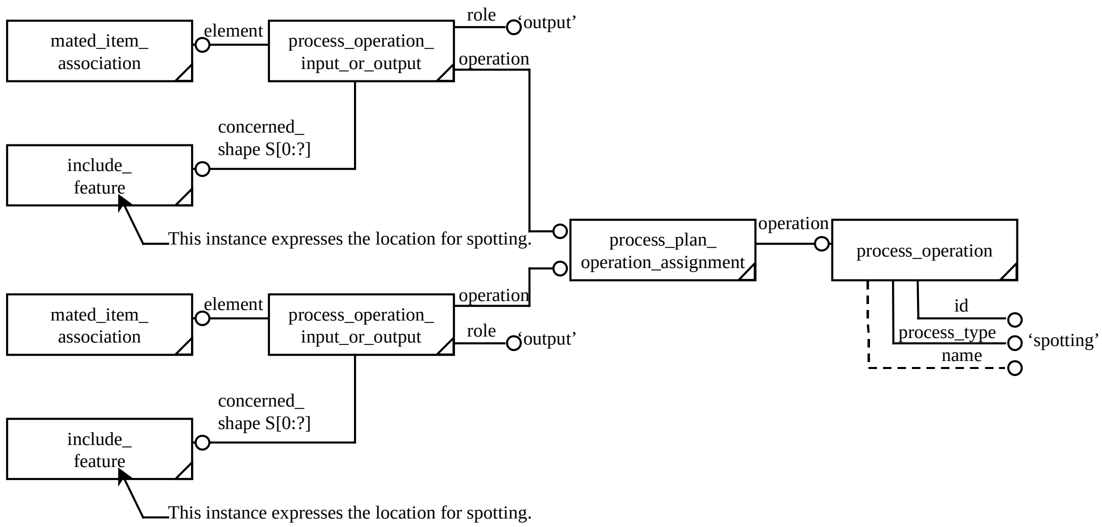

Figure 5-31 Representation of welding process operation

5.3.4.4 Discussion

We studied what work data relating to the reference design specifications is required for detailed design of press dies, welding equipment, and engine component processing equipment, and used this information to study if expression of the AP214 process plan (S8), form features (FFx), and assembly relationship (S3) can be expressed using mainly UoF.

By studying process plans with different characteristics, we were able to confirm the wide standardization of the application range.

The issues were as follows.

- In process design the specifying of the process type is very important, so in the future it is necessary to prescribe the attribute candidate of the Process_type, which is the attribute of process type.
- For processes that are in a parent-child relationship, the information for the product that is input or output of this process, is redundant,but some global rules are required to make it compatible.
- Process_property is used to express the process attributes, but an operational rule is required in the attribute name value.

In the future, a study must be made of actual equipment by using a prototype.

5.3.5 Rieter: Exchange of Sound Damping Part

Owner: GALIA, RIETER

Created: March 11, 1997

Reference Document: ISO TC 184/SC4/WG3/P19 N536

5.3.5.1 Abstract

This report presents the result of the mapping of data managed by the Design Office of Rieter Automotive France onto entities defined in the Application Reference Model of the application protocol ISO 10303-214.

This exercise is made in order to validate, with a real data case, the application reference model of the protocol. More precisely, it aims measuring the gap between this model and data currently managed by a french automotive company and envisioning the ways to reduce the possible unconsistencies.

The example is presented in clause 5.3.5.2.. Clause 5.3.5.3 lists the reference documents and used software. Clause 5.3.5.4 contains a synthesis of the mappings and the list of issues raised on the ARM of the protocol. The Clause below contains the STEP file that results from the instanciations. Finally, clause 5.3.5.6 presents a graphical view of the created instances.

5.3.5.2 User Description

5.3.5.2.1 Context

The example deals with a case of data transfer occurring between Rieter Automotive France and its contractor PSA Peugeot Citroen.

The case corresponds to the design of a sound damping part by Rieter from the data by PSA of an another part defining the "environment" of the part to be designed.

In a first time, PSA sends to Rieter a CAD file that contains the geometry of the "environment" part. This information is included in Rieter’s database. Then, the sound damping part is designed and sent to the contractor for approval.

5.3.5.2.2 Test case

- Rieter receives the following electronic message from PSA: XC.N61FR-.9630902480.OR.PED-DOU-COMAUTECOL.--N6QQ-A-E

- This message specifies that PSA has designed the part 963090248.OR that belongs to the family XC.N61FR-.G11.
'OR' identifies the version of the part.
The message also contains a CAD file defining the shape of the part.
- Rieter creates an own alias part (related to PSA part) identified C13570.S0--. C13570 is the identifier of the part. It also identifies the CAD file that contains the geometric data defining the shape of the part.
S0 indicates that the part is defined by a CAD file that contains a surface model.
-- identifies the version of the part.
- Rieter designs a sound damping part with the identifier C13571.S0--. The part has, like the initial one, an associated CAD file.
- Finally, this part and its CAD file are sent to PSA for approval.

5.3.5.3 Reference documents and used software

The example has been dealt with on the basis of the most recent available releases of the protocol.

The following documents have been considered:

- document ISO TC184/SC4/WG3/P19 N536;
- intermediate document dated 17/11/96;
- intermediate documents Word TOP1 et TOP2 dated 9/12/96.

The intermediate documents are available at the ftp server ftp.dik.mashinenbau.th-darmstadt.de.

Rieter data have been mapped, using the software ECCO (version 1.5.9a), developed by the german laboratory RPK.

5.3.5.4 Proposed mappings and difficulties encountered

5.3.5.4.1 Types and amount of created instances

- Application_context	1
- Cartesian_coordinate_space_3d	1
- Design_discipline_item_definition	2
- Digital_document	2

- Document_type 1
- External_document_version 2
- External_model 2
- General_classification 1
- Item 3
- Item_classification 1
- Item_shape 2
- Item_version 3
- Item_version_relationship 1
- Organization 2
- Person_or_organization_assignment 2
- Shape_description_association 2

- Total 25

5.3.5.4.2 Main mapping choices

The main mapping choices, representing the mapping of concept parts to created instances, are shown in Figure 5.3.5-1.

Concept	Created Instance(s)
Company Identification	Organisation
Part	Item + item_version
Part family	General_classification
Identification Rieter - identification PSA	Item_version_relationship
Association Part - CAD file	DDID + item_shape + shape_description_association + external_model
CAD file	Digital_document & external_document & external_document_version

Figure 5.3.5-1: Main mapping choices

5.3.5.4.3 Unconsistencies between Rieter's data and the ARM of AP214

5.3.5.4.3.1 Distinction between Product and CAD data

The real data do not distinguish, as much as the protocol, information that identify parts and information that identify CAD data.

As the protocol implies to give a value to entity attributes (e.g. external_model.id) that do not have an explicit corresponding in Rieter's data, we have had to complete some instances with invented information in order to get them valid.

5.3.5.4.3.2 Units of geometric models contained in CAD files

The protocol implies to know the length and plane angle unit used in an external CAD file with it is referred to when diescribing the shape of a part (**external_model**). This information is not available in Rieter's data.

Note: this problem would not have occured if we had dealt with the relationship between the part and its CAD file, with using an instance of **external_document_assignment** (referring to a ddid) and not an instance of **item_shape**. But, we would have then lost the role of the file (i.e. file describing the shape of a part).

5.3.5.4.4 Changes needed in the ARM of the protocol

5.3.5.4.4.1 Digital_document

This entity has for attributes†:

- name (inherited from external_document);
- file_name.

It is probably one too much since we do not know exactly what is the exact difference between these attributes.

=> replace the attribute **file_name** by the attribute **digital_location** with the following litteral definition:

"**digital_location** specifies the digital directory where the file is stored.

NOTE - the name of the file is given with external_document.name. "

5.3.5.4.4.2 General_classification & specific_classification

In the example, the initial part belongs to the part family XC.N61FR-.G11.

In order to transfer this information, two entity types may be instantiated:

- specific_classification;
- general_classification.

=> The clause 4.2 of the protocol should be amended to avoid such an alternative.

Therefore, using a value of **specific_classification.classification_type**, different from those proposed in the permissive list of clause 4.2.422.2 should be forbidden.

Besides, the role of the attribute **general_classification.name** is not clear. In the example, shall it contain "famille de piËces" or "XC.N61FR-.G11"? Shall the value "famille de piËces" be stored in the attribute **item_classification.description**?

=> It is necessary that the definition of **general_classification.name** be precised and that one or more examples be given.

5.3.5.4.4.3 External_model & geometrical_model

These entities have an attribute **role** that is expected to define the "rÙle of the external model". This attribute is not included in the right entity or it should be renamed.

In fact, a geometric model or an external model is only a collection of representation items. It gains a meaning only when it is associated with product data (e.g. it may be the representation of the shape of a given part).

Note: a model may have several roles (e.g. representation of the shape of a part and representation of physical limits for another).

=> move both attributes **role** in the entities that assign a model to product data, i.e. in **shape_description_association** and in **template_instance**.

5.3.5.4.4.4 Description of the Item_shape with an external file

The protocol enables to associate a CAD file to either the entity design_discipline_item_definition (via external_document_assignment) or to the entity item_shape (via shape_description_association).

=> in order to avoid contradictory implementations, it is needed to add in clauses 4.2 and/or 5.2, a rule, probably only informal, forbiding to describe the shape of a part with an external file without creating an instance of item_shape.

5.3.5.4.4.5 shape_description_association

The information regarding units used in a CAD file being usually included in the file, the possible reference to **external_model** through the attribute **defining_geometry** is problematic.

=> replace, in **shape_definition_select**, **external_model** by **digital_document**.

5.3.5.5 STEP File Results from Instanciations

```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION(
$,
’2’);
FILE_NAME(’c:\utilisateurs\huau\ap214\exemples\rieter.stp’,
’1996-12-16T’,
$,
$,
’ECCO RUNTIME SYSTEM BUILT-IN PREPROCESSOR V1.5.9a’,
’ECCO RUNTIME SYSTEM V1.5.9a’,
$);
FILE_SCHEMA((’ARM_SCHEMA_214’));
ENDSEC;

DATA;
#0=ORGANIZATION(’RIETER Automotive France’,
$,
’S.A.’,
’OG1’,
$,
’78410 Aubergenville’);
#1=ORGANIZATION(’PSA Peugeot Citroen’,
$,
’Client’,
’OG2’,
$,
$);
#2=ITEM(’9630902480’,
’’,
’ensemble pedalier pour vehicule auto-ecole’);
#3=ITEM(’C13570’,
$,
’ensemble pedalier pour vehicule auto-ecole’);
#8=ITEM_VERSION(’OR’,
```

```
#2,
$);
#9=ITEM_VERSION('__',
#3,
$);
#10=ITEM_VERSION_RELATIONSHIP(#8,
#9,
$,
'alias');
#11=PERSON_OR_ORGANIZATION_ASSIGNMENT(#2,
#1,
'owner');
#12=PERSON_OR_ORGANIZATION_ASSIGNMENT(#3,
#0,
'owner');
#13=(DIGITAL_DOCUMENT(
'CFAO',
'Binaire',
$,
$,
$,
$,
$)
EXTERNAL_DOCUMENT(
'C13570',
$,
'XC.N61FR-.G11.9630902480.OR.PED-DOU-COMAUTECOL.--N6QQ-A-E',
#14,
$)
EXTERNAL_DOCUMENT_VERSION(
'--')
);
#14=DOCUMENT_TYPE($,
'S0',
'Modele surfacique ou "solide"');
#15=(DIGITAL_DOCUMENT(
'CFAO',
'binaire',
$,
$,
$,
$,
$)
EXTERNAL_DOCUMENT(
```

```
'C13571',
'',
$,
#14,
$)
EXTERNAL_DOCUMENT_VERSION(
'--')
);
#16=DESIGN_DISCIPLINE_ITEM_DEFINITION('',
'DDID1',
#8,
(#18));
#18=APPLICATION_CONTEXT($,
'Etude protection acoustique',
'Conception');
#20=ITEM('C13571',
$,
'encapsulage moteur');
#21=ITEM_VERSION('__',
#20,
$);
#22=GENERAL_CLASSIFICATION((#2),
'famille de pieces',
$,
$,
'XC.N61FR-.G11',
$);
#23=CARTESIAN_COORDINATE_SPACE_3D($,
('mm',
'degre decimal'));
#24=EXTERNAL_MODEL(#13,
#23,
'OM1',
'donnees CAO',
$);
#25=ITEM_SHAPE(#16,
'forme de la piece fournie par PSA');
#26=SHAPE_DESCRIPTION_ASSOCIATION(#25,
#24);
#27=EXTERNAL_MODEL(#15,
#23,
'OM2',
'donnees CAO',
$);
```

```
#28=DESIGN_DISCIPLINE_ITEM_DEFINITION($,
'DDID2',
#21,
(#18));
#29=ITEM_SHAPE(#28,
'forme de la piece resultat');
#30=SHAPE_DESCRIPTION_ASSOCIATION(#29,
#27);
ENDSEC;
END-ISO-10303-21;
```

5.3.5.6 Graphical View on Created Instances

Figure 5.3.5-2 shows a graphical view on the created instances.

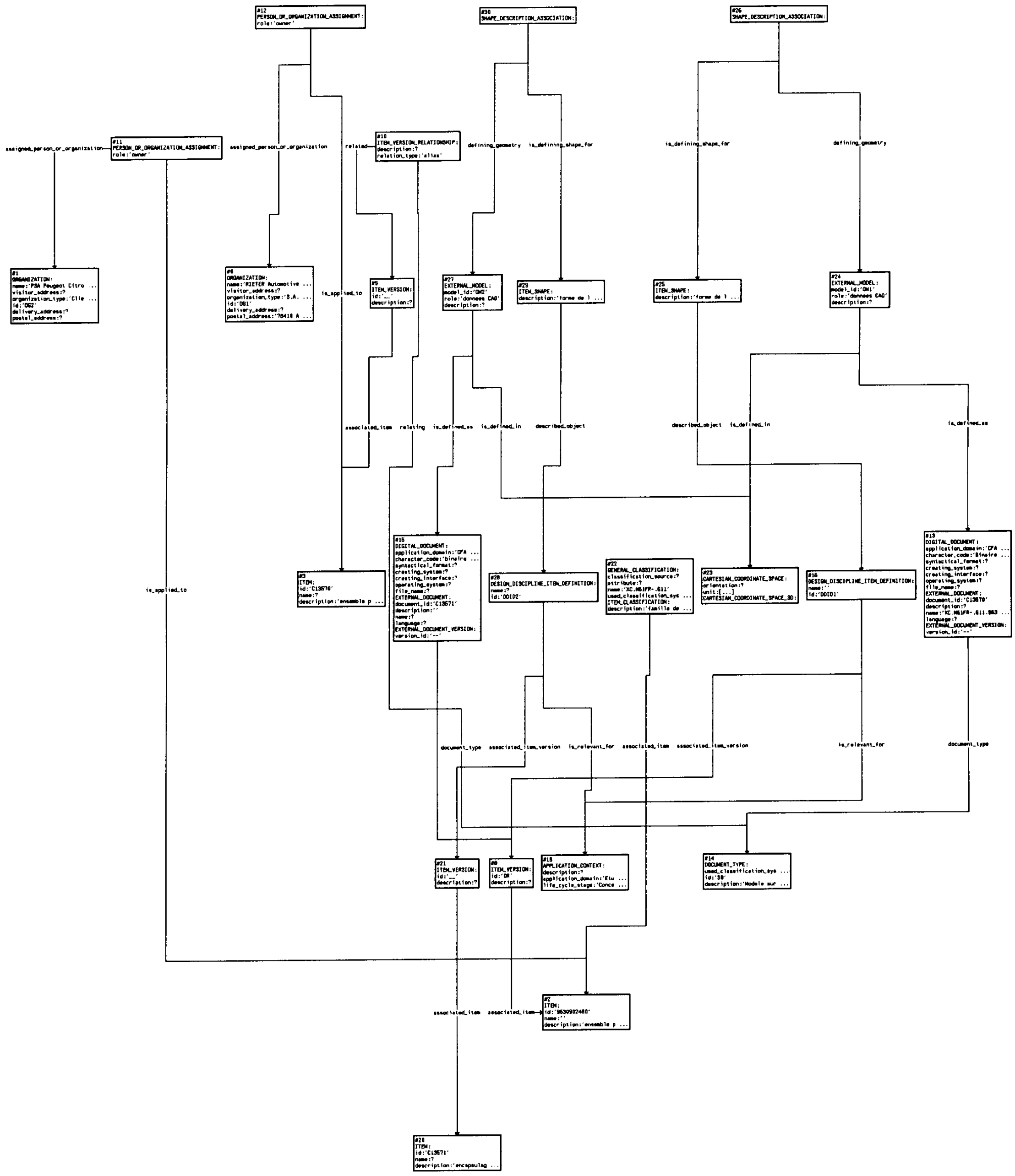

Figure 5.3.5-2: Graphical view on created instances

5.3.6 Scania: Functional Description of 300 l Fuel tank for Truck

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Reference document: ISO TC184/SC4/WG3 N756

5.3.6.1 Abstract

This example deals with the design description of a specific fuel tank for a commercial truck.

5.3.6.2 User Description

Trucks may be equipped with one, or several optional fuel tanks.

The tanks may be of different volume, shape or material, and be fitted on one, or both sides of the chassis. All tanks on a truck have always the same material and shape.

At least one fuel tank is mandatory.

The fuel tank may be placed in different positions on the chassis side member, depending of customers' preference, or other equipment.

Therefore the following specifications applies...

- FPC 74B Fuel volume, right side; 300 dm3
- FPC 77B Fuel volume, left side; 300 dm3
- FPC 235D Fuel tank material; steel
- FPC 1370G Fuel tank sectional area; general

Further specifications are needed to ensure that the fuel tank really is valid for the product class truck.

- FPC 1A Product class Truck

Other specifications appear in the example, but they are however of no importance for the principle.

To start from the very top, the enterprise Scania has several product_class objects, among which Truck is one.

The different product_class objects are separated from each others by means of configuration.

The product_class Truck, is divided into product_functions, among which, 'Fuel Supply' appears.

The product_function object, in its turn, is subdivided into product_component objects, like 'Fuel Tank RH' for which the item '1 368 977' appears as a technical_solution

5.3.6.3 Mapping to the AP214 ARM

See EXPRESS-G instantiation diagrams:

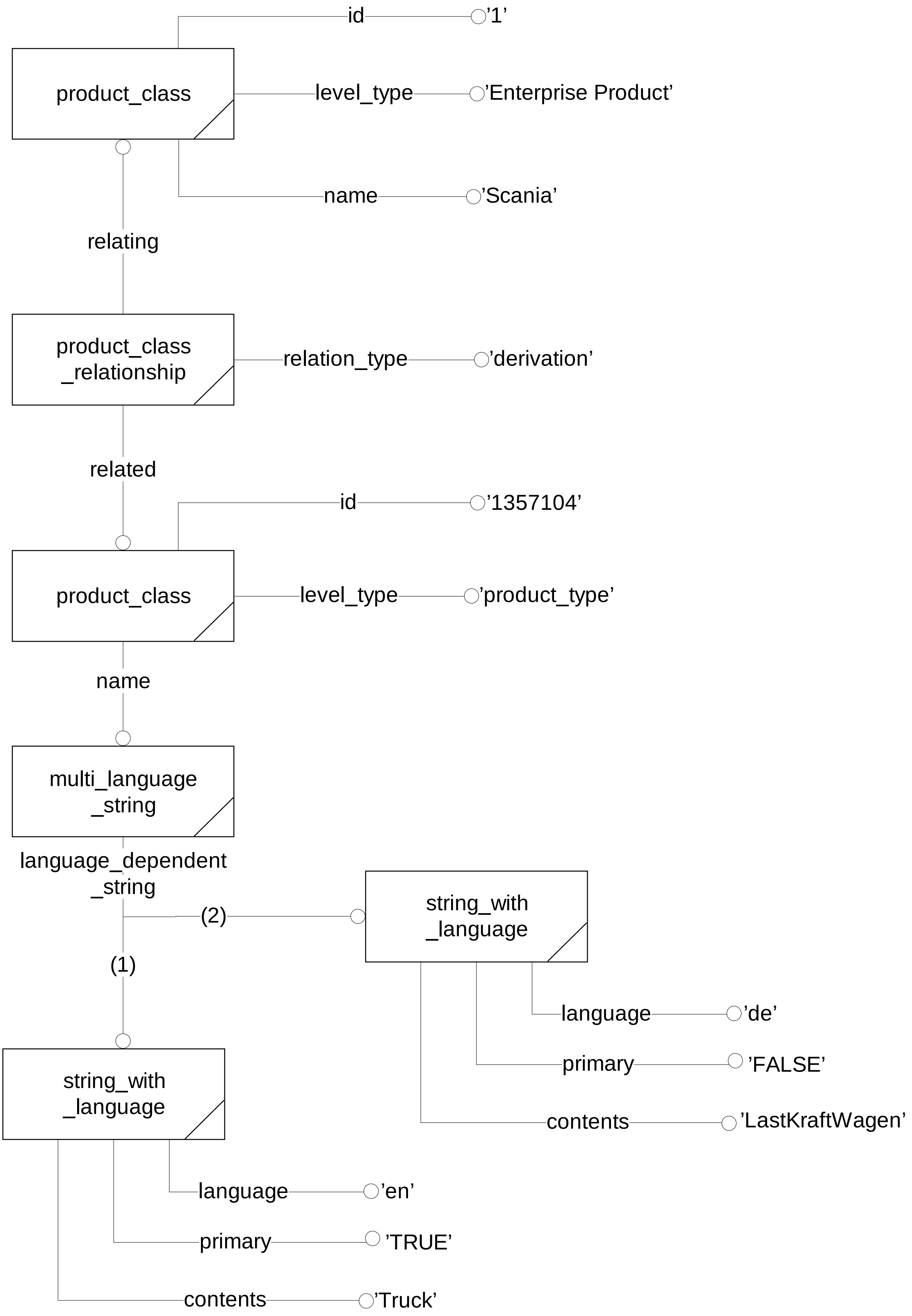

Figure 5.3.6-1 Product_class_relationship

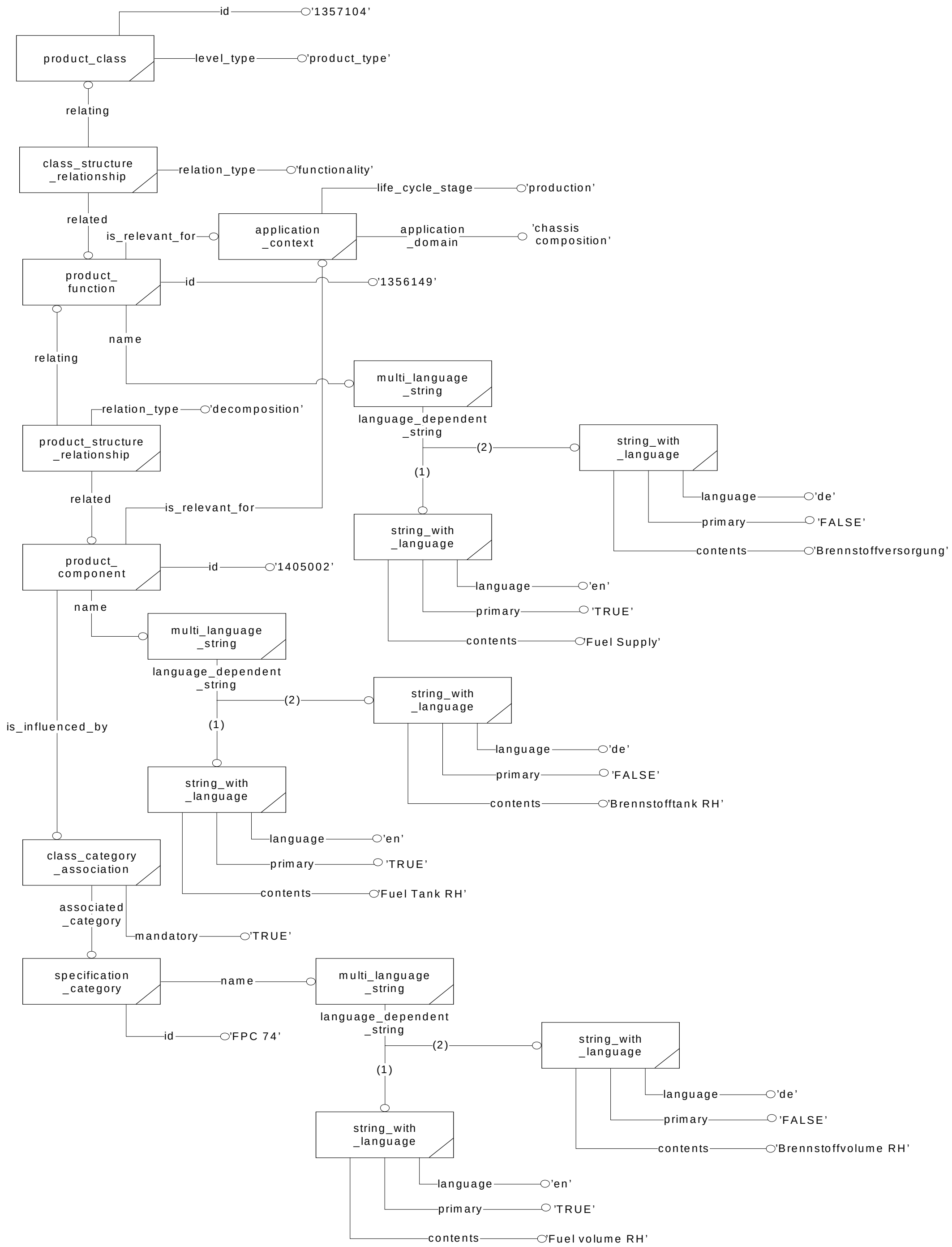

Figure 5.3.6-2 Product_structure_relationship

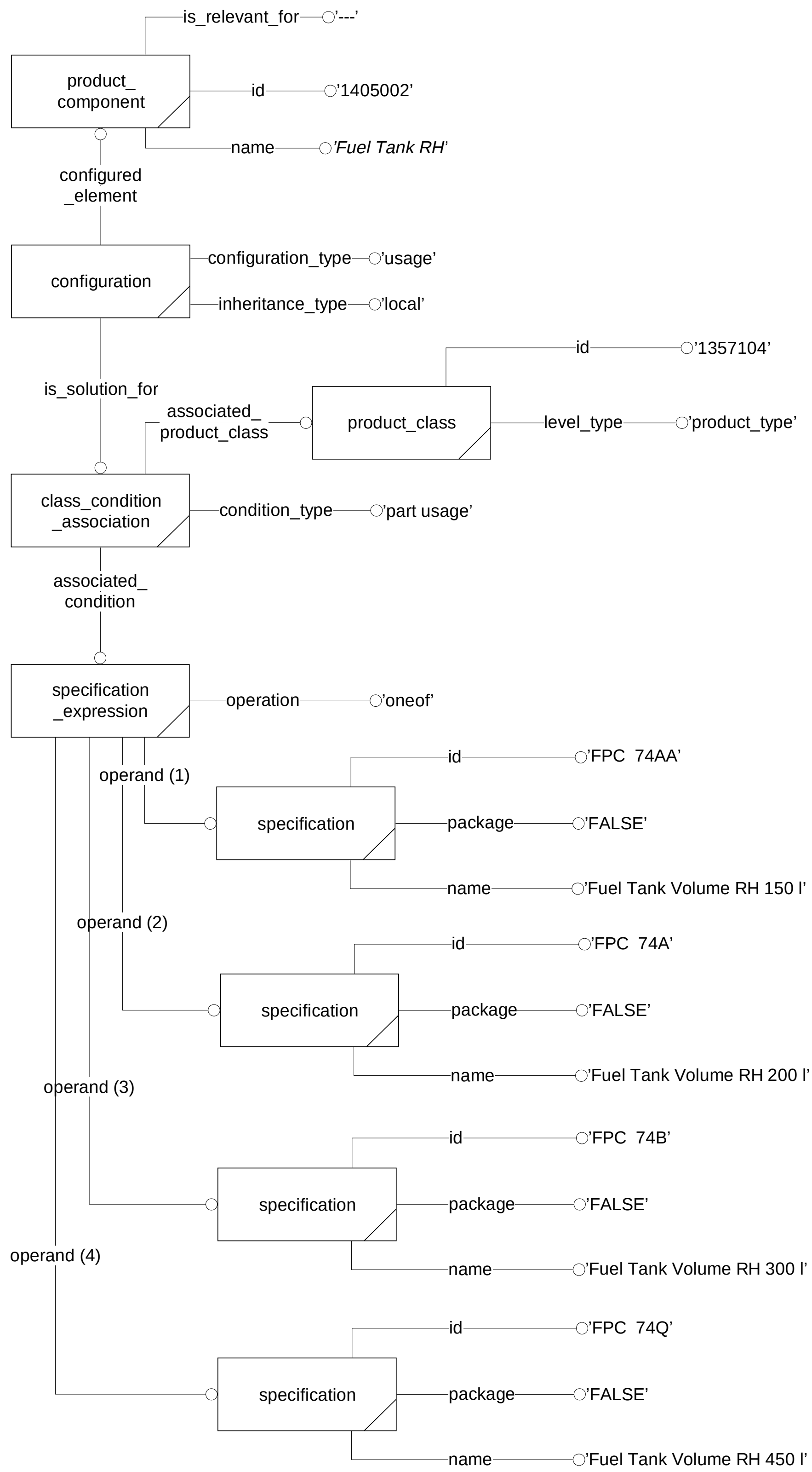

Figure 5.3.6-3 Configuration, for product_component

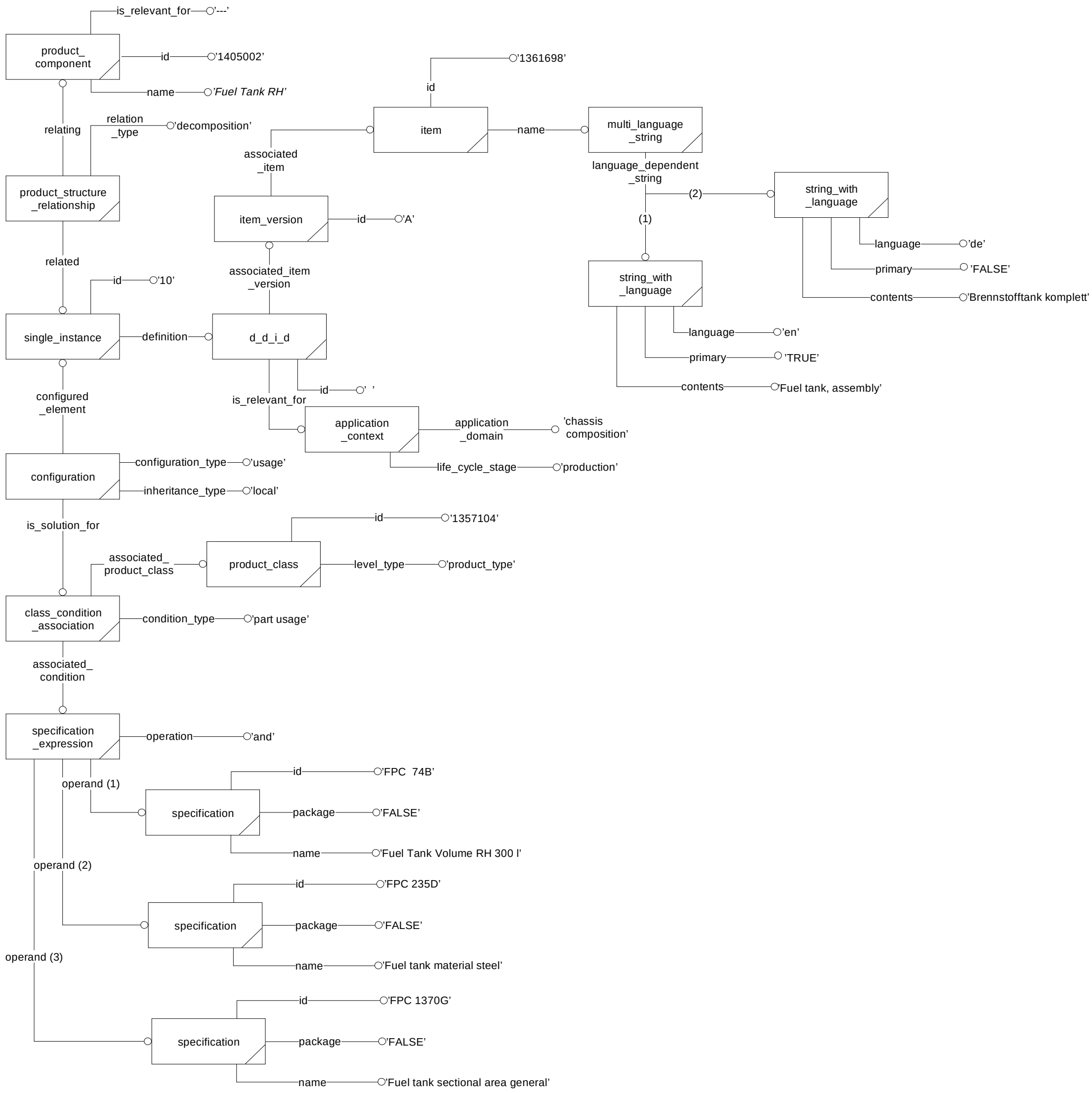

Figure 5.3.6-4 Product structure, Item level

5.3.6.4 Discussion

Configuration_type ‘usage’ needed for product_function and product_component. There is no need to pass through a class_condition_association for all conditions, a more direct association is preferred which would be possible if the condition is applied in the association between application objects.

Language code, according to ISO 639-1, in combination with ISO 3166, should be used, to permit variants of a language, like Brazilian Portuguese, or UK English etc.

5.3.7 Scania: Substitution of Item version in a certain usage.

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5.3.7.1 Abstract

This example simulates a substitution of an item_version in a specific place in a product structure.

5.3.7.2 User Description

A single_instance, with the id ‘10’ is substituted by the single_instance ‘15’.

This exchange is a result of activity, with id; 251696, to which a corresponding effectivity object, with the id 251696 is assigned.

Separate effectivity_assignment objects are assigned for the exchange, the role attributes ‘planned start’, and ‘planned stop’ is used.

The both item_instance objects are defined with separate instances of d_d_i_d.

5.3.7.3 Mapping to the AP214 ARM

See EXPRESS-G instantiation diagram shown by Figure 5.3.7-1 Substitution of Item_version in certain use, on page 125.

'1998-09-25'

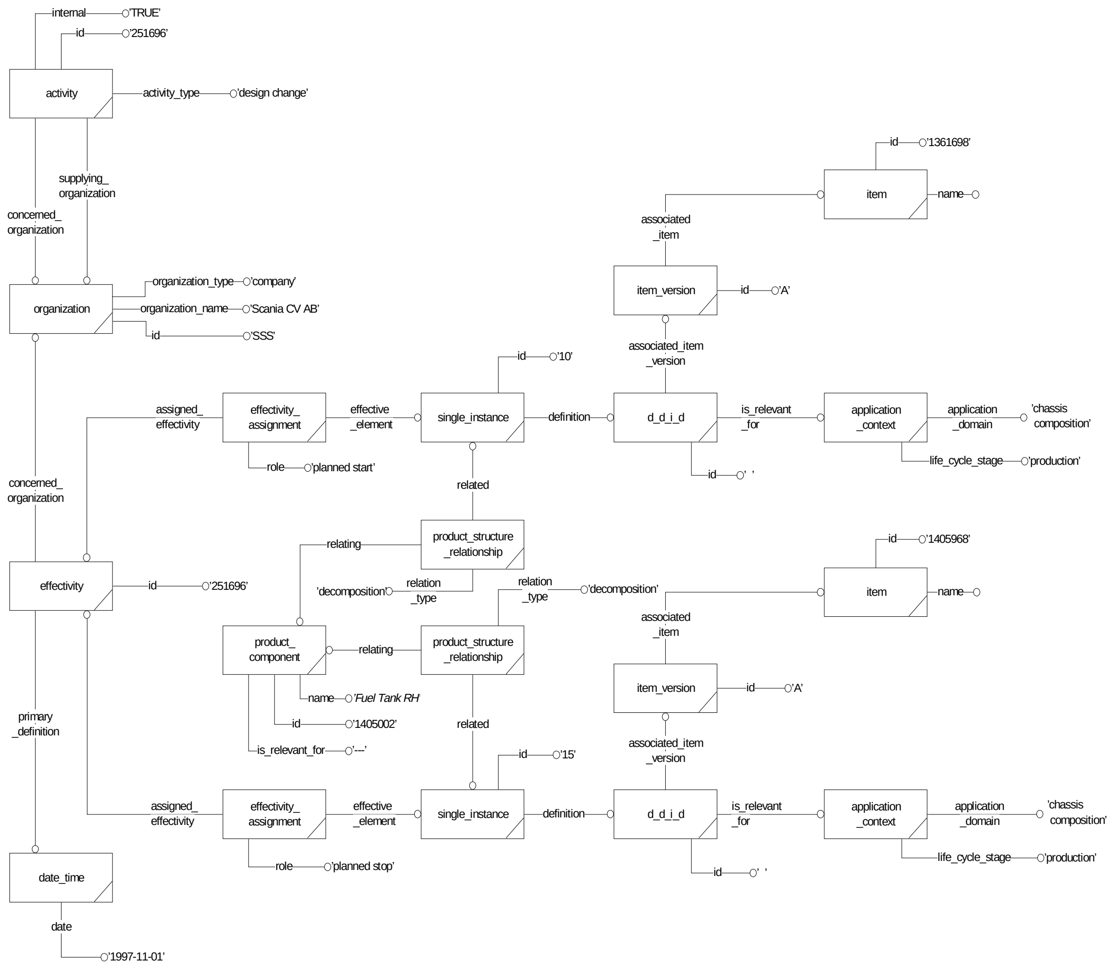

Figure 5.3.7-1 Substitution of Item_version in certain use

5.3.7.4 Discussion

See comment in clause 5.3.8.4 on page 127 and 5.3.9.4 on page 129.

5.3.8 Scania: Substitution of Item version in all its uses, on a certain date.

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5.3.8.1 Abstract

This example simulates a simple substitution of an item_version, the exchange is supposed to be effectuated on a certain date.

5.3.8.2 User Description

An item, with the id; 1 361 698, with the present version; A, is to be substituted with the item_version; B.

Effectivity_assignment objects are applied to the two item_version objects, where version ‘A’ has the role; ‘planned stop’, while the effectivity_assignment object for the substituting item_version ‘B’ has the role; ‘planned start’.

Both effectivity_assignment objects relate to the same effectivity object, for which a date is defined as primary_definition.

5.3.8.3 Mapping to the AP214 ARM

See EXPRESS-G instantiation diagram shown by Figure 5.3.8-1 Item_version exchange, page 127.

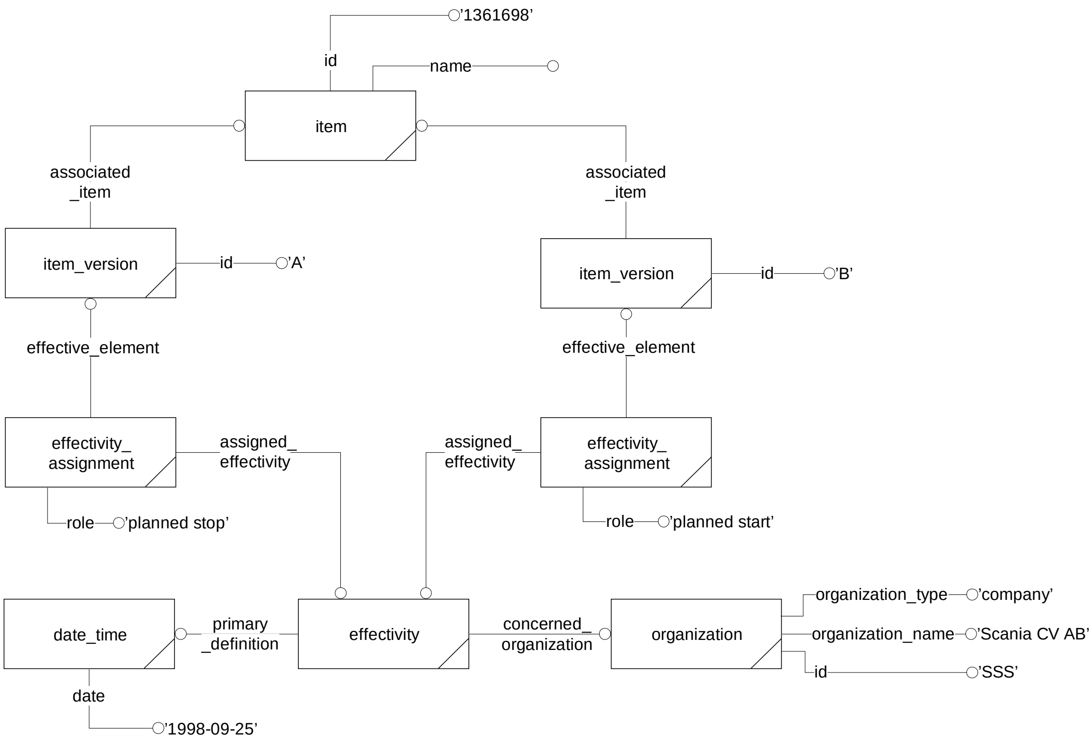

Figure 5.3.8-1 Item_version exchange

5.3.8.4 Discussion

The example shows a significant improvement in comparison to the CD-version…

The role attribute 'planned...' and 'actual...' should be separated in 2 different attributes, if needed. Otherwise a separate mechanism, or routine, must be developed to confirm a planned date, as to have been effectuated.

The role 'planned' and 'actual' should be applied as a separate attribute to the entity effectivity.

The 'required' role should be a separate attribute on the entity effectivity with the allowed values 'at latest', 'exact', 'at earliest' and 'as planned'.

5.3.9 Scania: Substitution of Item version as result of an activity.

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Reference document: ISO TC184/SC4/WG3 N756

5.3.9.1 Abstract

This example simulates a substitution of an item_version, as a result of an activity.

5.3.9.2 User Description

An item, with the id; 1 361 698, with the present version; A, is to be substituted with the item_version; B.

The same example as shown by Figure 5.3.8-1, on page 127, is used.

This time, the effectivity is identified by an id attribute, where the id is the same as for the corresponding activity.

The same organization is referred to as ‘concerned_organization’ from both effectivity and activity objects.

5.3.9.3 Mapping to the AP214 ARM

See EXPRESS-G instantiation diagram as per Figure 5.3.9-1 Design change, carried out using Activity shown on page 129.

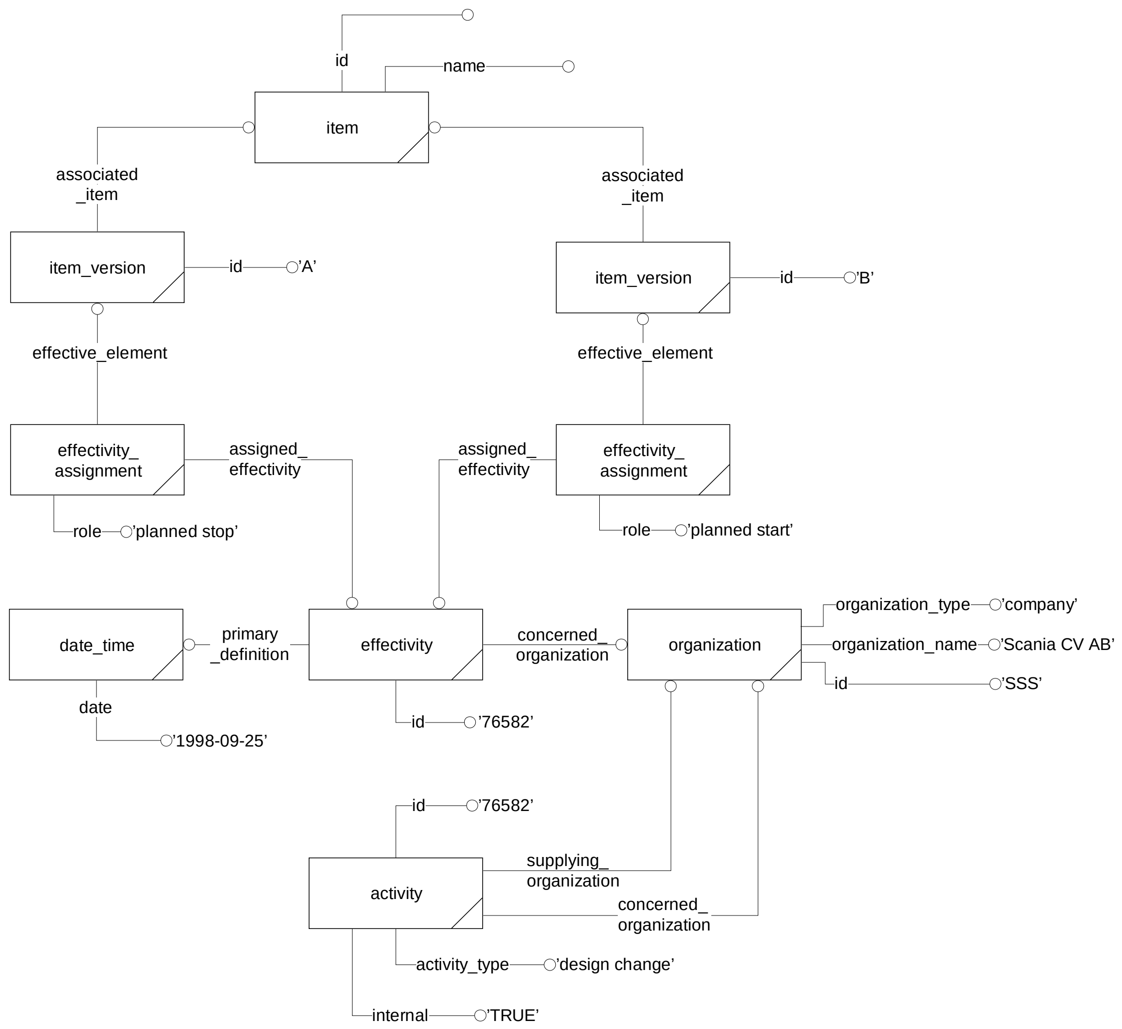

Figure 5.3.9-1 Design change, carried out using Activity

5.3.9.4 Discussion

This solution works, but is not explicit. We would prefer a stronger relationship between effectivity, and activity than what is offered by equal identities.

When this solution is used, a careful management of effectivity and activity identities is required.

See also comment in clause 5.3.8.4 on page 127.

5.3.10 TOYOTA HONDA: Form Features For Engine Component Design

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Created: September 1, 1998

Reference document: ISO TC184/SC4/WG3 N756

5.3.10.1 Abstract

In this paper we are using a four-cylinder twin-cam 16 valve engine cylinder head design process as a case study in handling form features added to the product shape. Even though it is solid and has a complex shape, a cylinder head is a representative automobile component. The shape of a cylinder head includes many areas expressed as bosses and ribs as well as machined areas. Although the complexity of the modeling shape during the design process will vary depending on the application and the aim of the designer, the design final output must not only precisely express the shape of the completed product, but is also a product model that expresses the intent of the designer. For this project, we studied several specific examples to see how characteristic areas of product models are expressed and to see if these posed problems in the AP214's ARM.

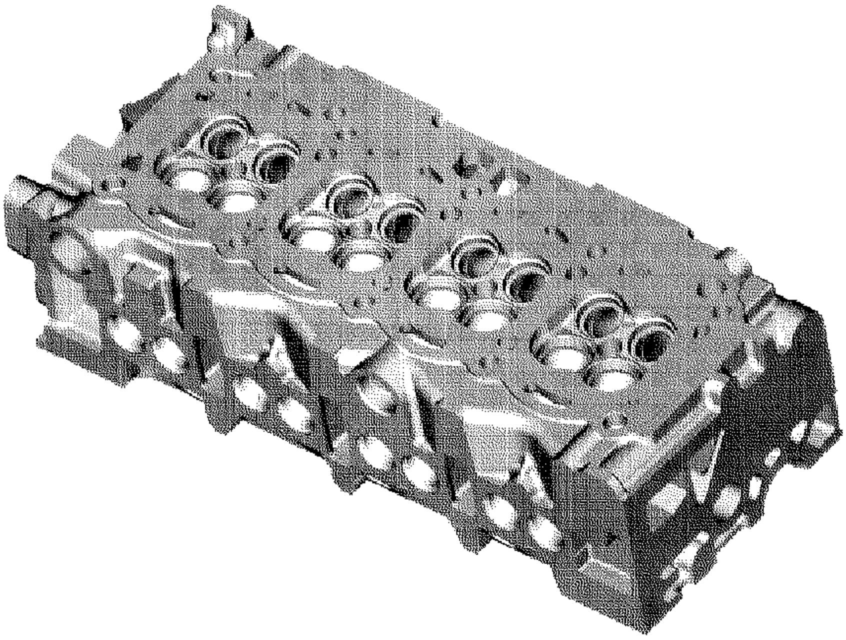

Figure 5-1 Example of a cylinder head

5.3.10.2 User Description

5.3.10.2.1 Expectations For Form Features In The Design Process

The results expected of form features in the design process are listed below.

a) Better efficiency using a user interface designed for the designers.

  - Modeling input work
  - Shape correction using feature parameters

b) Better efficiency from transmitting the intent of the design

  - Create drawings based on the shape
  - Shape change for analysis and rapid prototyping
  - Machining process design, NC calculations

5.3.10.2.2 The Reason A Cylinder Head Was Selected For The Case Study

As described below, the reason a cylinder head was selected is that it plays an important role in automobile development.

a) Because the cylinder head has the most complex shape of the functional parts and, therefore, requires the most design man hours and time, there is a strong desire to improve the design efficiency of this part.

b) Because this part has a major impact on automobile performance, it is often subject to a variety of analysis and rapid prototyping, so it is hoped to make this process more efficient.

c) Because there are many areas that are machined and the machining methods are complex, it is hoped to be able to automate the machining process design by transferring over product data.

In addition, a cylinder head is a suitable subject in view of its shape because there are many types of form features that can be expressed and there are more patterns than other functional parts.

5.3.10.2.3 Scope Of Study

This study was conducted to identify the positions that are representative and featuristic of cylinder heads, to describe these by expressing them in form features, and to achieve efficient shape creation and to transmit the design intent. There are also examples that were described by expressing the same shape using different form features. In addition, when form features were used in machining process design, if information, such as surface finish and tolerance, are not included as well as the shape of the processed area, then it is not possible to automate process design, so this study also shows the relationship between the form features and the tolerance.

The following items were studied.

a) More efficient shape creation

a-1) Appropriateness of the form feature expression for each engine area

a-2) Merits, demerits, and featuristic usage of complex form feature expressions in the same area

b) Design intent transmission

b-1) Drawing pattern expression method

b-2) Method for adding tolerance information

5.3.10.3 Mapping to AP214 ARM

5.3.10.3.1Ignition Plug Hole (when Placed_feature is used)	5.3.10.3.2 Ignition Plug Hole (when Included_feature is used)	5.3.10.3.3 Ignition Plug Hole (when using General_feature)	5.3.10.3.4 Ignition Plug Hole (when tolerance is used with shape)	5.3.10.3.5 Ignition Plug Hole (when using tolerance without	5.3.10.3.6 Valve Seat Hole	5.3.10.3.7 Cam Bearing Cap Installation Screw Hole	5.3.10.3.8 Manifold Installation Boss and Rib			
	•	•								Included_feature
•			•	•	•	•	•			Placed_feature
		•								General_feature
									Chamfer	Transition_feature
									Edge_round	
					•				Fillet	
•	•					•				Thread_feature
•	•		•	•	•	•			Rectangular_pattern	Replicate_feature
									Circular_pattern	
									General_pattern	
•	•		•	•	•	•			Compound_feature_in_solid	Process_feature_in_solid
									Slot_feature	
								Rectangular_closed_pocket_in_solid	Pocket_feature_in_solid	
								Rectangular_open_pocket_in_solid		
							•	General_pocket_in_solid		
								Circular_boss	Boss_feature	
								Rectangular_boss		
							•	General_boss		
•	•		•	•	•	•			Round_hole	
							•		Rib_feature	
										Process_feature_in_panel

Table 5-1 Correlation between actual examples and form features

5.3.10.3.1 Ignition Plug Hole (when Placed_feature is used)

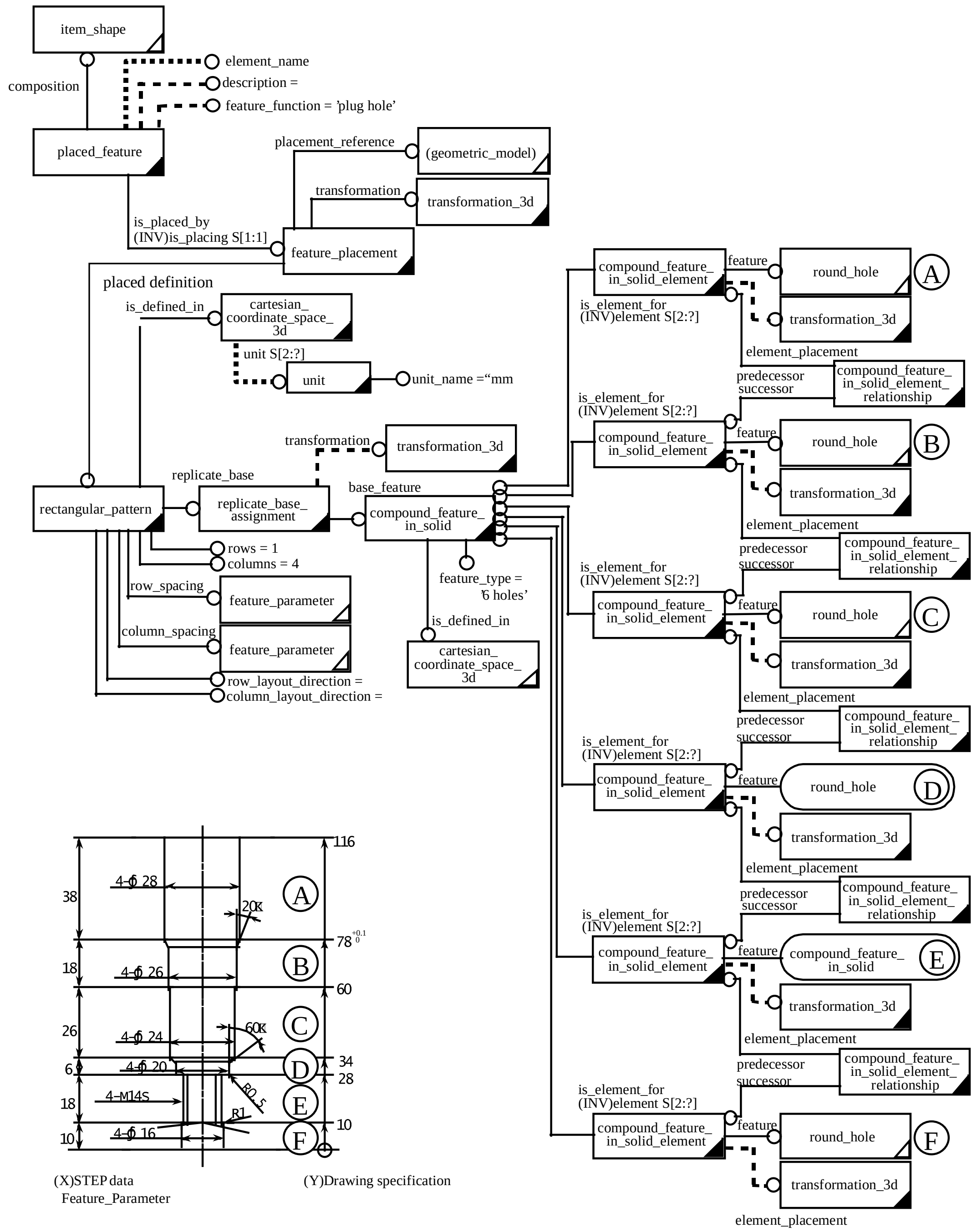

Figure 5-2 Cross section of ignition plug hole and instance of it using Placed_feature

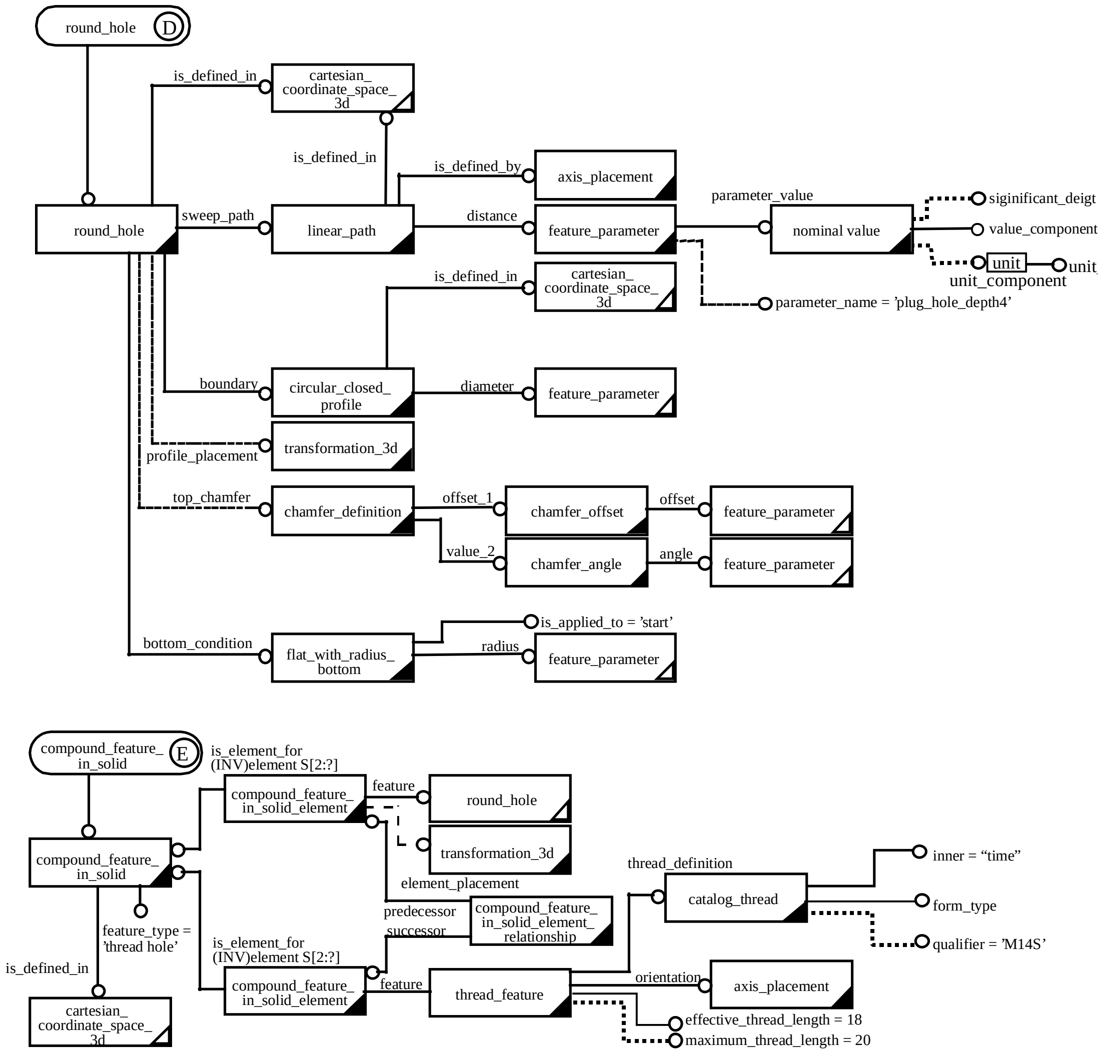

Figure 5-3 Instance of ignition plug hole using Placed_feature (continued)

When defining this shape, the form feature construction will be a Round_hole's Compound_feature that has dimensions (X) like those shown on the left of Figure 5-2 (Cross section of ignition plug hole and instance of it using Placed_feature). However, the actual drawing specifications are the dimension specifications (Y) on the right side of the drawing, so conversion work between (X) and (Y) must be done.

The A-bottom dimensions on the drawings include tolerances and this is described in Item 5.3.10.3.4

5.3.10.3.2 Ignition Plug Hole (when Included_feature is used)

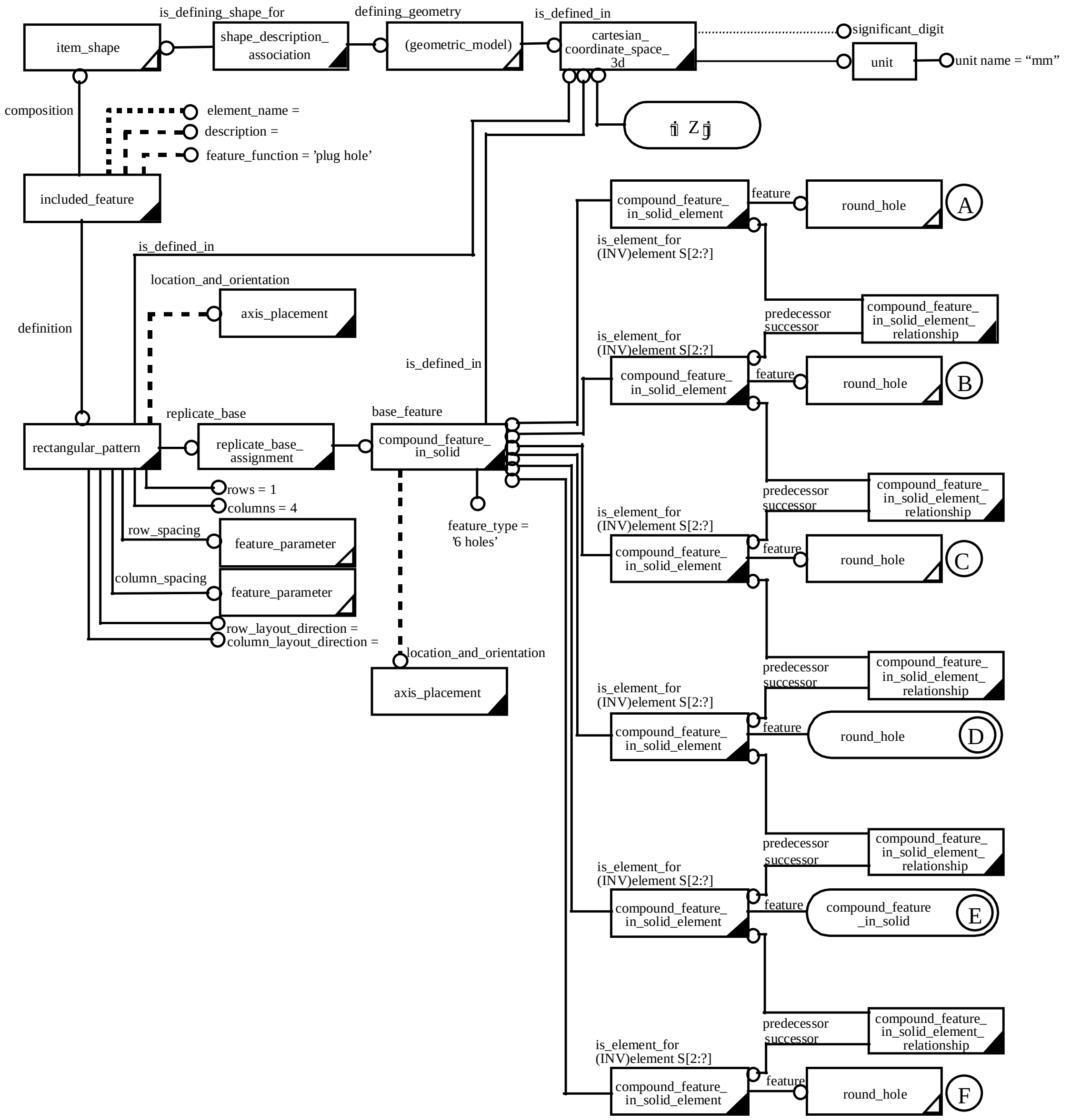

Figure 5-4 Instance of ignition plug hole using Included_feature

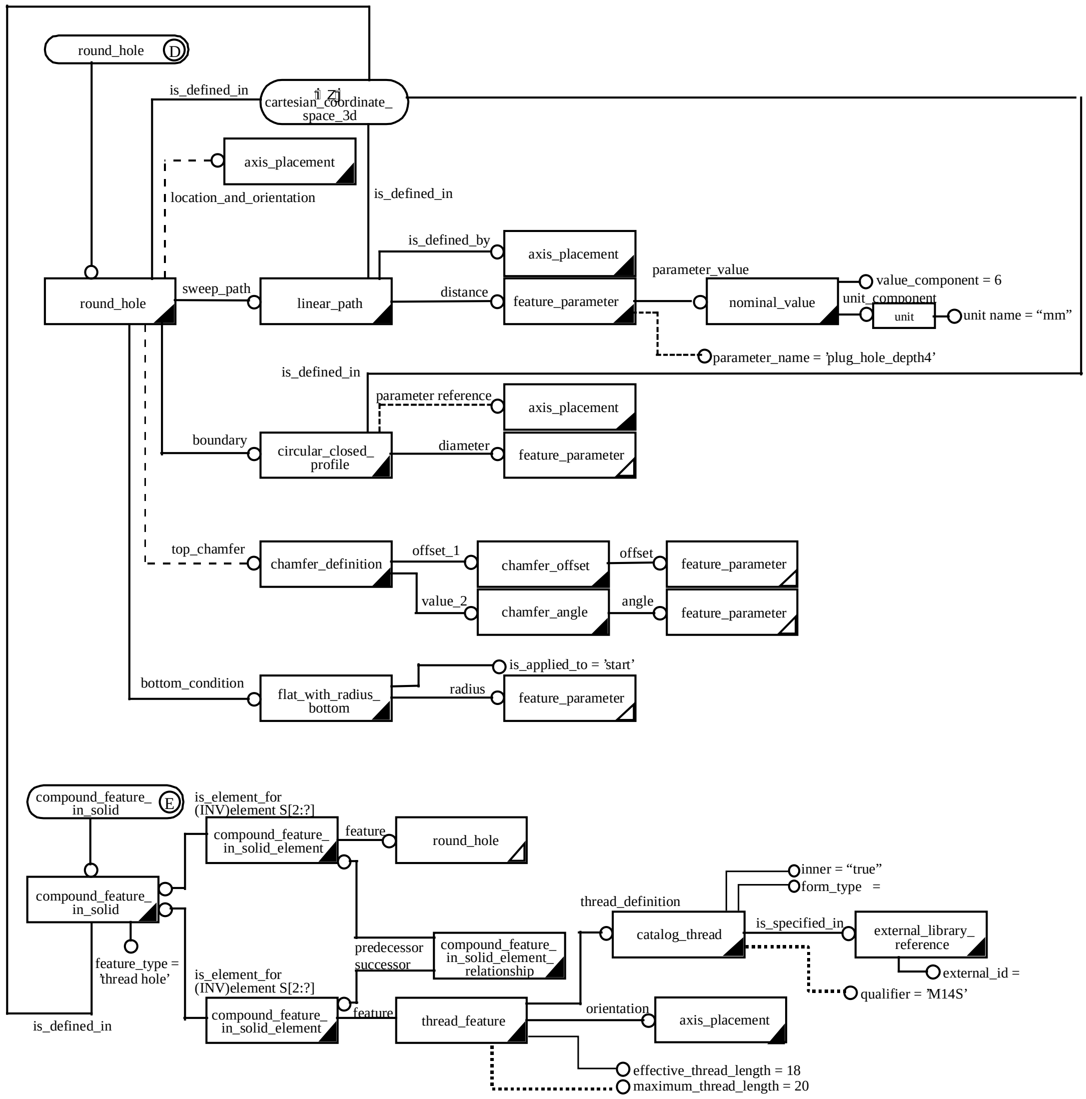

Figure 5-5 Instance of ignition plug hole using Included_feature (continued)

The comment for this item is the same as that for Item 5.3.10.3.1

Incidentally the difference of concept between Axis_placement and Transformation is not easy to understand. If there is an explanation of the difference in the document, it is useful.

5.3.10.3.3 Ignition Plug Hole (when using General_feature)

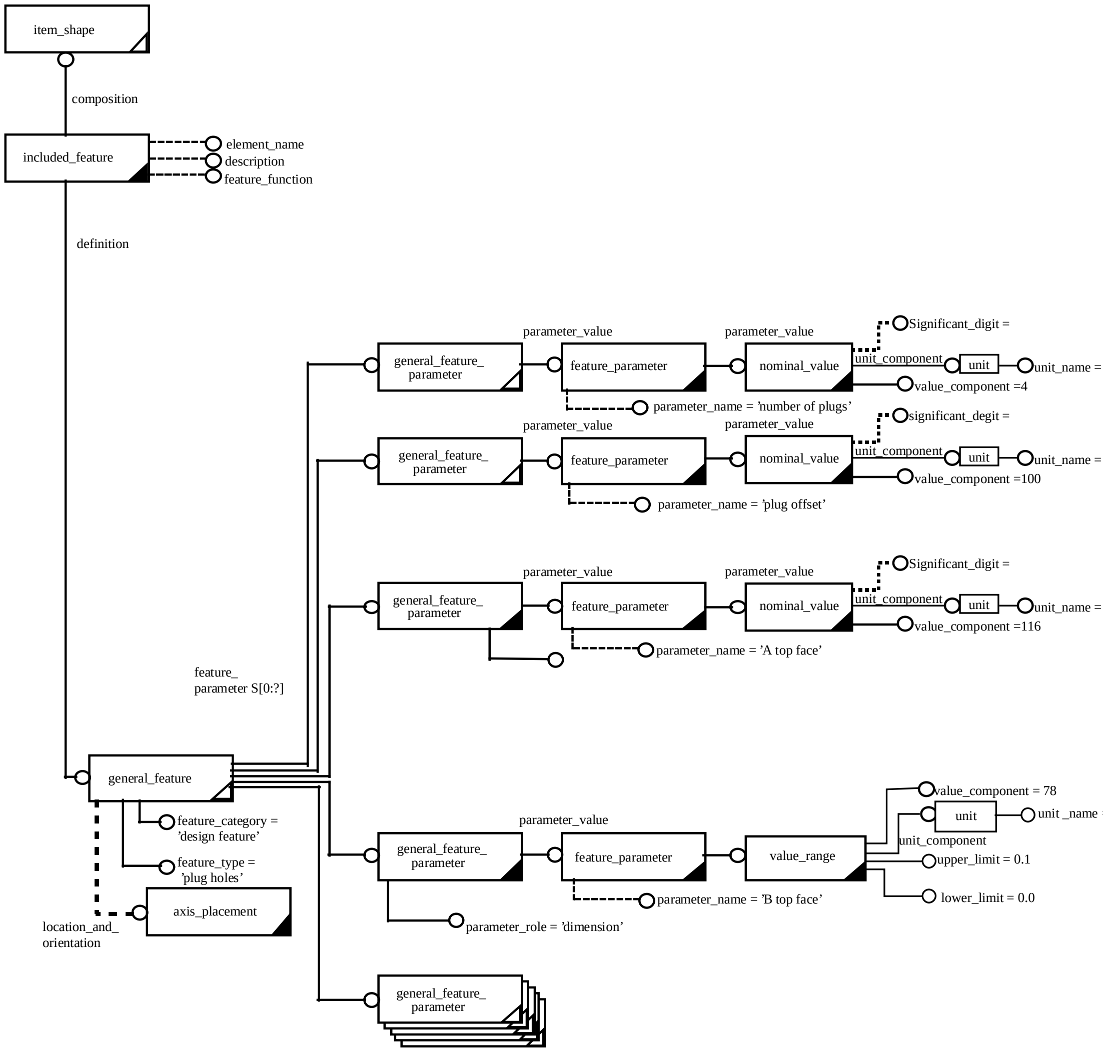

Figure 5-6 Instance of ignition plug hole using General_feature

When General_feature is used, all the shape dimensions and tolerances can be expressed using General_feature_parameter, so the data structure appears simple. However, if the meaning of the parameter is not understood then data conversion will not be successful.

The Replicate_feature cannot be configured using General_feature, so the number of plugs and offset values are set in the Feature_parameter.

5.3.10.3.4 Ignition Plug Hole (when tolerance is used with shape)

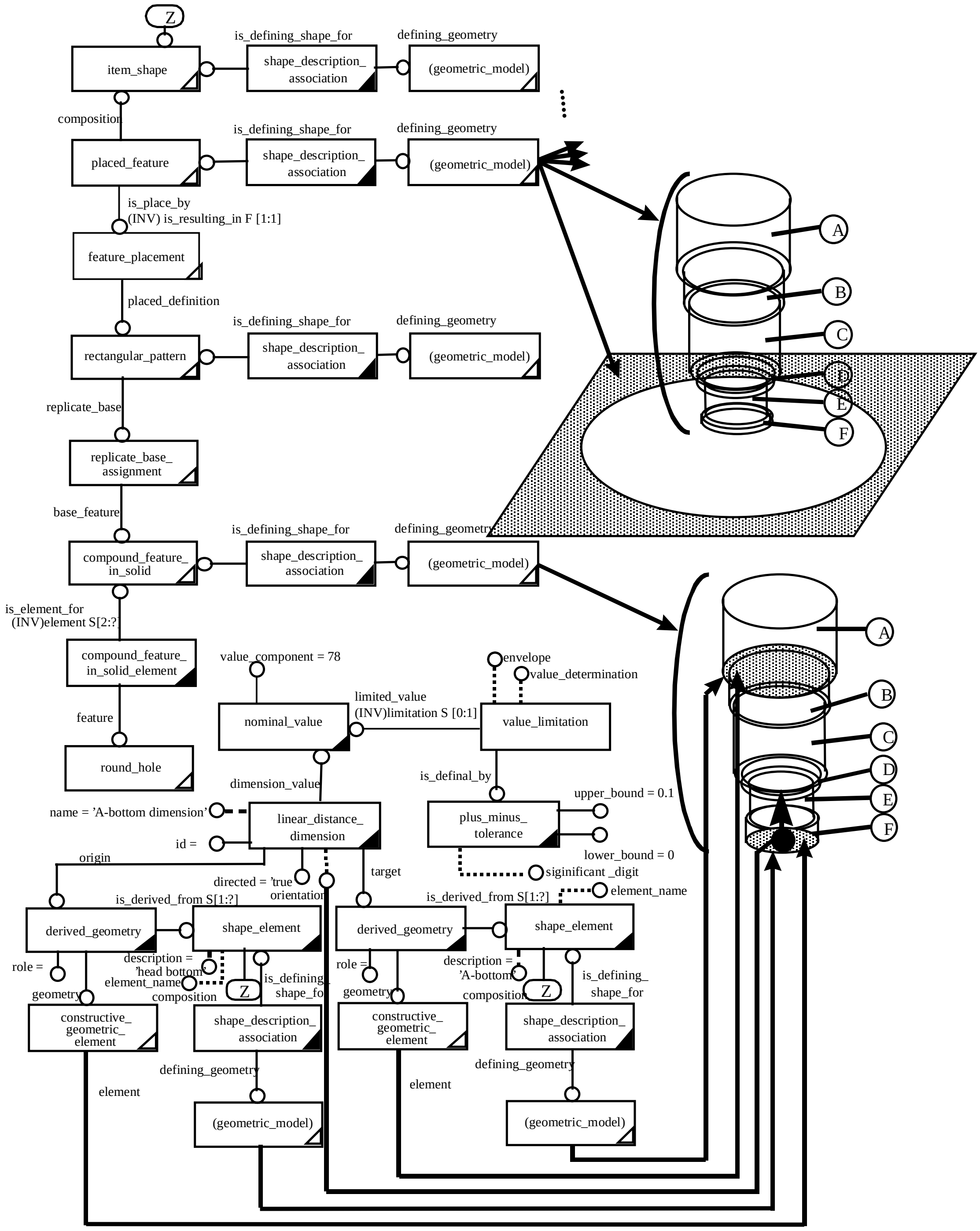

Figure 5-7 Instance of ignition plug hole when using tolerance with shape

The concept for dimension tolerance differs from the feature definition, the tolerances must be expressed by way of Geometric_dimension. If tolerances are directly added to Feature_parameter of Round_hole, tolerance accumulation will occur, creating a discrepancy between the (X) and (Y) dimensions.

In this example the A-bottom dimension should be expressed in the Feature_definition space. The geometric elements that are defining Shape_aspect are in the Feature_definition space, but the composition of Shape_aspect must refer Item_shape; this is not fit.

5.3.10.3.5 Ignition Plug Hole (when using tolerance without shape)

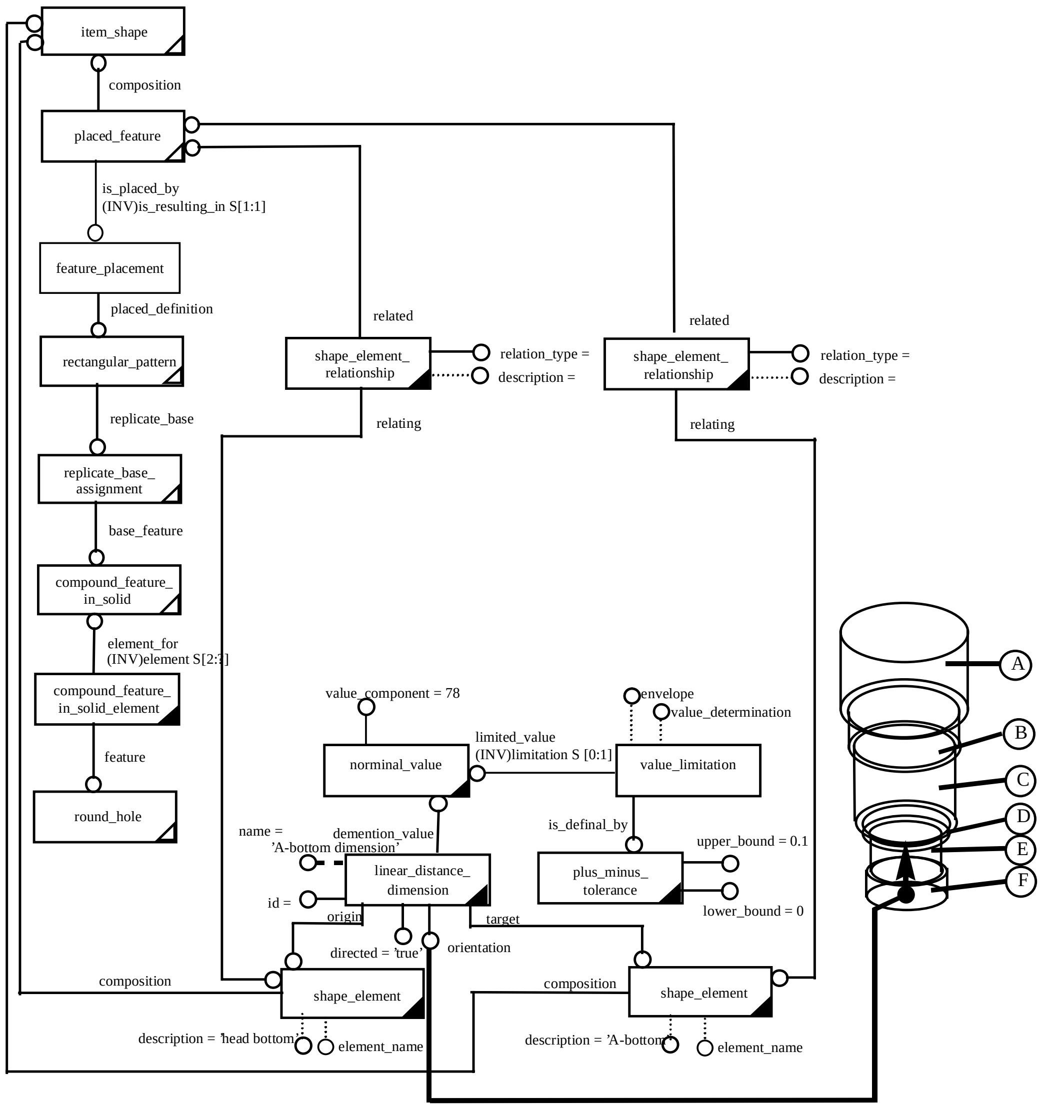

Figure 5-8 Instance of ignition plug hole when using tolerance without shape

To specify the elements for Dimension_tolerance when without shape, the Name attribute of Linear_distance_dimension and the Description attribute of Shape_aspect is used. So there is a danger of losing the accuracy of data conversion. The geometric elements associated with Dimension_tolerance on the level of Feature_definition is needed.

5.3.10.3.6 Valve Seat Hole

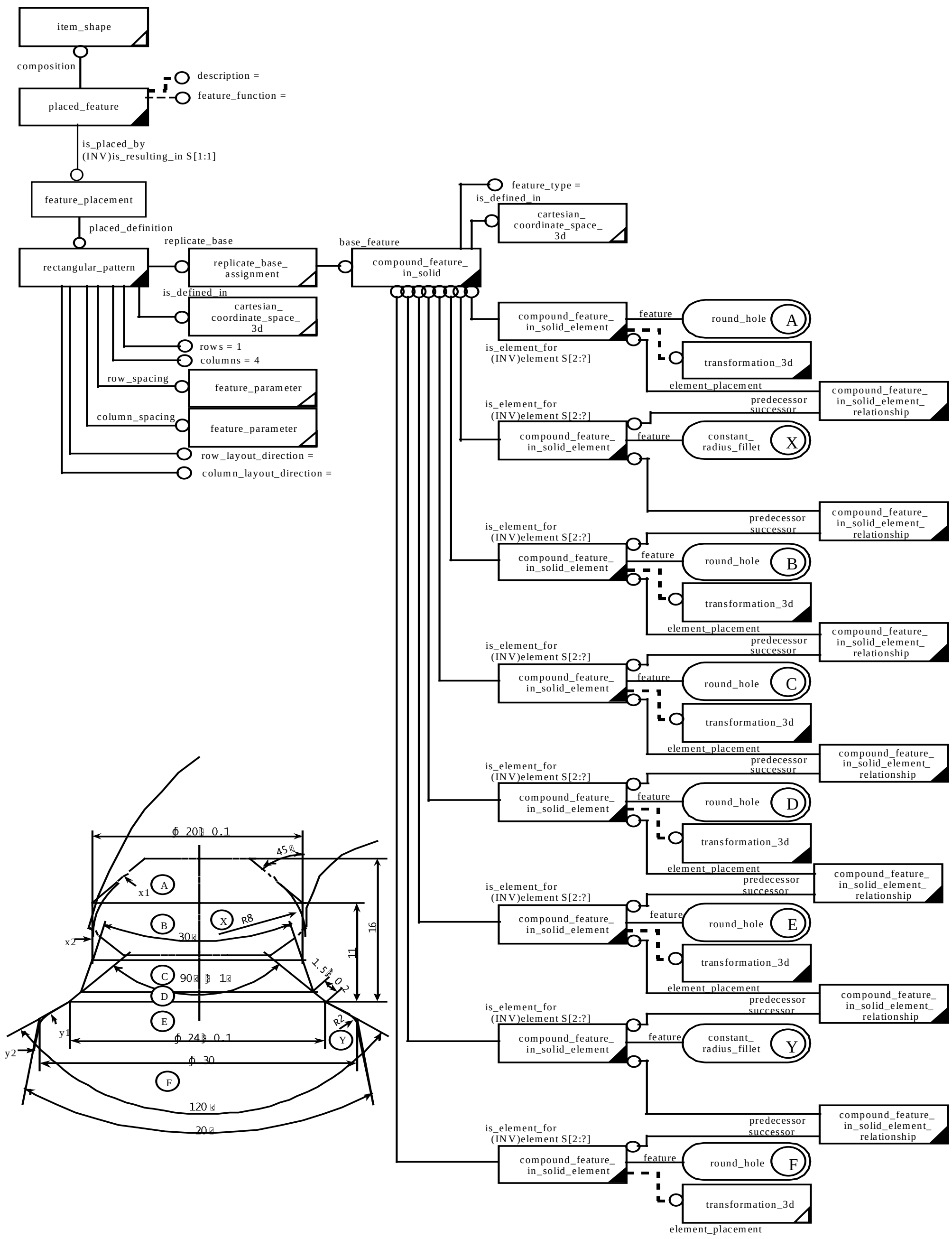

Figure 5-9 Cross section and instance of valve seat hole

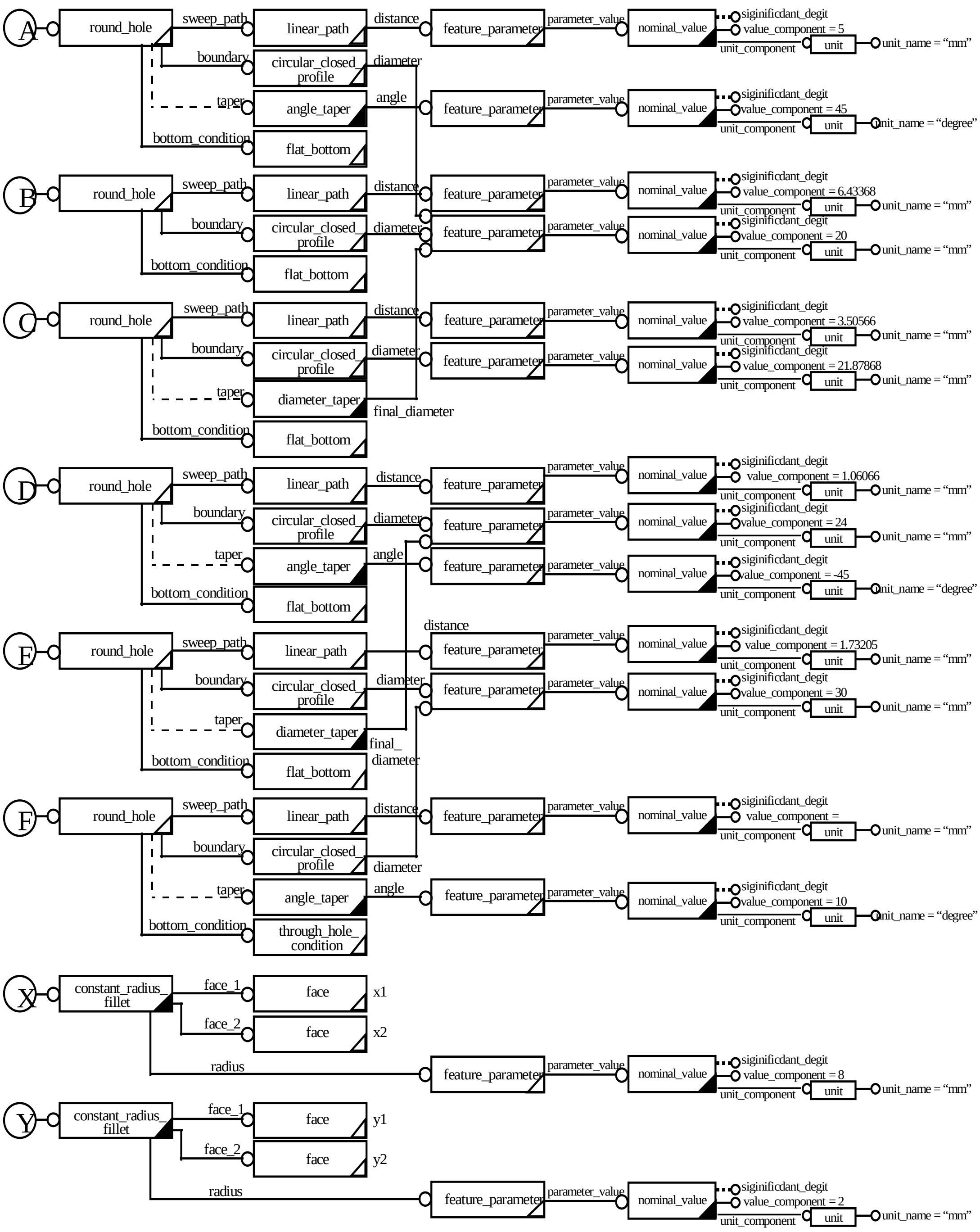

Figure 5-10 Instance of valve seat hole (continued)

The instance shown here is expressed using a compound shape of several Round_hole and Fillet. For this reason the values of several Feature_parameter of Round_hole have numerical values not envisioned by the designer and several hole shapes cannot be expressed directly using the dimensions intended by the designer. In consideration of the shape definition expression for this area, the designer may think that using General_feature, which is a rotating body rotated by General_profile and Circular_closed_path, is a better expression. It is clear that this area can be expressed by AP214, but which expression is suitable depends on whether or not there is a difference between the shape definition method and the AP214 output expression as well as the expression desired by the receiving side, and this is a future issue.

5.3.10.3.7 Cam Bearing Cap Installation Screw Hole

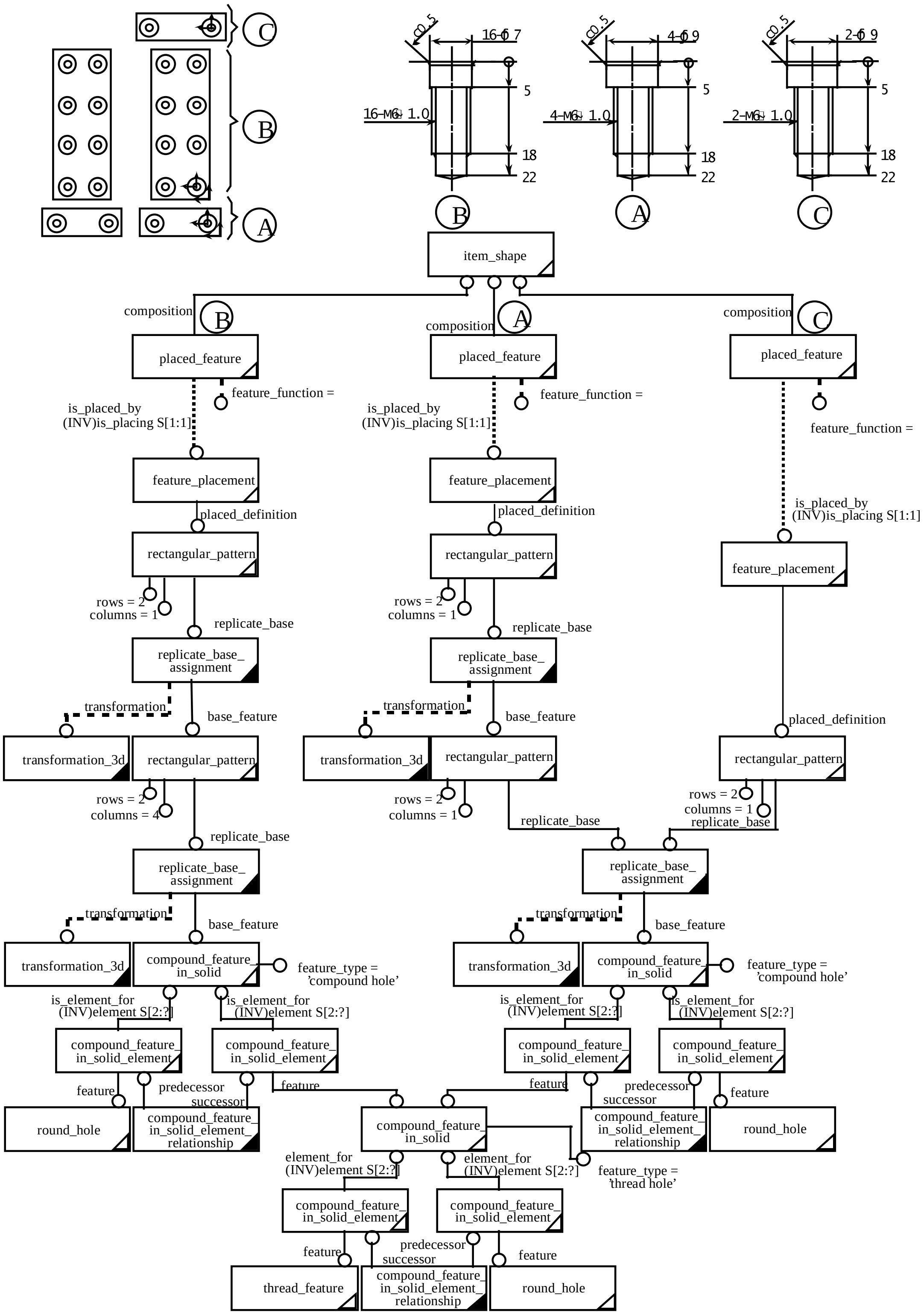

Figure 5-11 Location, cross section and instance of cam bearing cap installation screw hole

No problems were found in this example.

5.3.10.3.8 Manifold Installation Boss and Rib

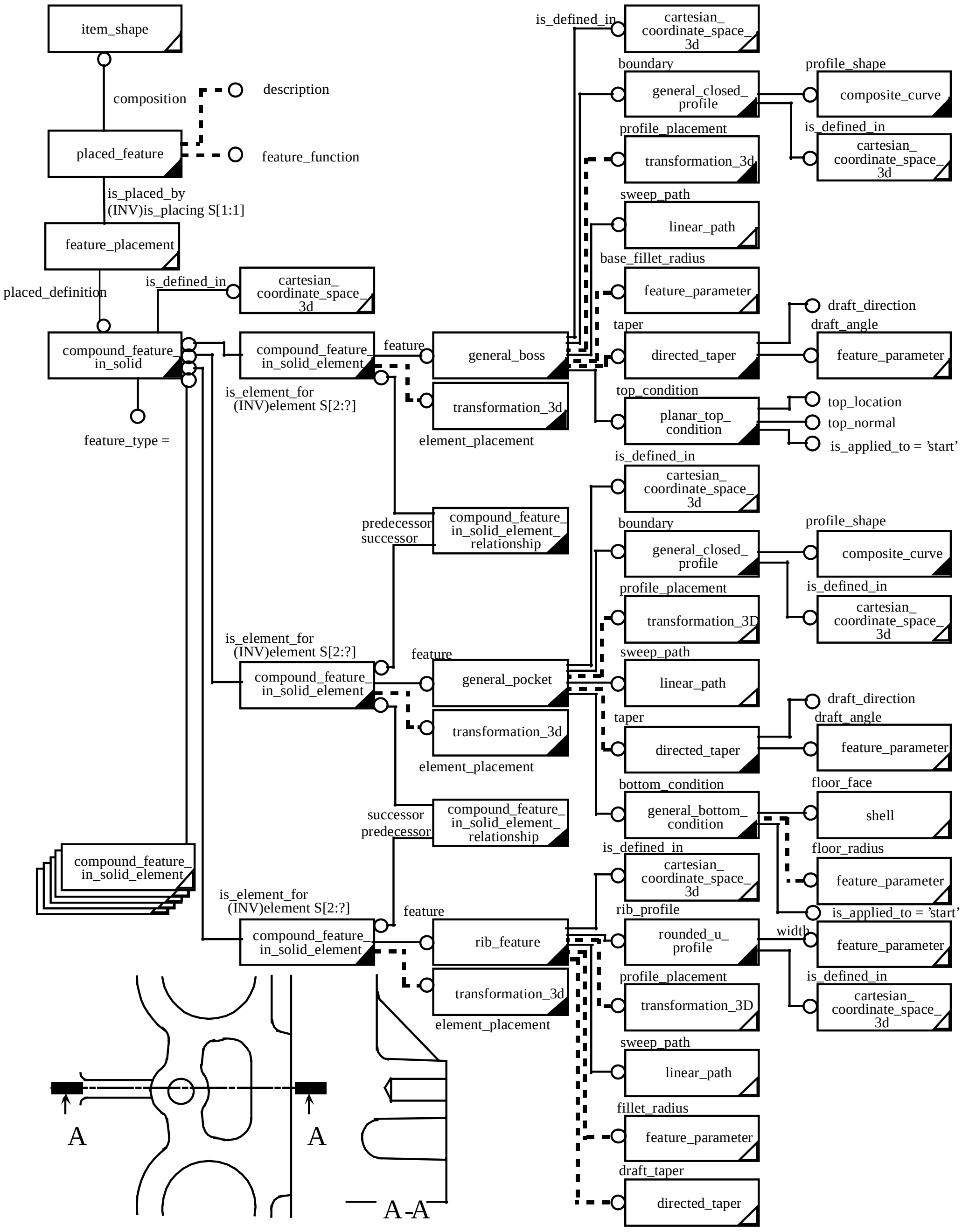

Figure 5-12 Cross section and instance of manifold installation boss and rib

No problems were found in this example, either.

5.3.10.4 Discussion

5.3.10.4.1 Parameter Expression Units

Because Feature_parameter has units, the parameter values can be expressed in the intended units, but it seems that the following parameters that can be simply referenced do not have units and that the intended units cannot be directly expressed.

However, this issue is fixed in AIM.

Affected parameters:

Maximum_depth of Slot_feature

Maximum_depth of Bead_feature

End_length of Linear_bead_end_type

Effective_thread_length of and Maximum_thread_length of Thread_feature

Angular_offset of Circular_offset_pattern

5.3.10.4.2 Existence of Tolerances

The following methods are used to define tolerances.

a) Individually add tolerance data.

b) Omit individual tolerances and use default tolerances.

c) Do not have tolerances.

Because the current ARM cannot differentiate between b) and c), there is the problem that it is unclear whether or not tolerances are added to the parameters. For example, with the example of an ignition plug hole the upper and lower positions of each hole, which comprise compound holes, are specified as the distance from the bottom surface of the head, so a tolerance will make this dimension meaningless. However, the hole feature specifies the hole length, and if this length has a default tolerance then non-conformities will be created.

5.3.10.4.3 Conclusion

We conducted this study using an engine cylinder head shape design process as a case study to see if that product's model featuristic areas can be described using the current AP214 ARM form feature expressions, if shape creation can be made more efficient, and if the design intent can be transmitted.

As mentioned in Item 5.3.10.2.3, the following items were studied.

a) More efficient shape creation

  a-2) Merits, demerits, and featuristic usage of complex form feature expressions in the same area

b) Design intent transmission

  b-1) Drawing pattern expression method

  b-2) Method for adding tolerance information

For a-1) the form feature expressions are possible for the engine areas using the current ARM and presented no problems.

For a-2) we conducted this study using Placed_feature, Included_feature, and General_feature (refer to Items 5.3.10.3.1, 5.3.10.3.2, and 5.3.10.3.3). With the exception of the difference between transformation and placement, there was no major difference structurally between Placed_feature and Included_feature. However, General_feature was significantly different from the other two and has a very simple data structure. Even though there is the merit that the parameters can be expressed as shown in the drawings, this includes the problem of what to do when the meanings of the parameters are commonized.

b-1) Because the dimension symbols in the drawing and the parameters during feature creation differ, the values specified by the dimensions cannot be used unmodified when creating features (Items 5.3.10.3.1, 5.3.10.3.2, 5.3.10.3.6, 5.3.10.3.7, and 5.3.10.3.8). There must be a conversion from the drawing symbol values to the feature parameter values. This is what causes the related tolerance problem in b-2).

b-2) There was no particular problem in expressing tolerances using General_feature (refer to Item 5.3.10.3.3, expression is possible by adding Dimension_tolerance to Feature_parameter). However, as studied in b-1), we found that Dimension_tolerance cannot be directly added to Feature_parameter and tolerance should be expressed using Derived_geometry by way of Geometric_dimension, when the feature parameters and drawing parameters differ. In this case, there is no problem when used with shape, but there is the problem that data conversion loses its accuracy when without shape .

When used with shape, the geometric elements associated with Geometric_dimension are in feature definition space, but the composition attribute of Shape_aspect associated with Geometric_dimension refers a shape in featured shape space; both space should be identical.

In the future, addition to the desktop study conducted this time, the advantage of feature modeling must be verified. We need to develop a prototype CAD/CAM system that handles form features and conducts data conversion for a variety of component models that handle features, to verify smooth data conversion from the design process to the manufacturing process, the accurate transmission of the design intent, and rationalization of the machining data creation, etc.

5.3.11 Volvo: Configuration control

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Created: *09/09/98*

Reference document: ISO TC184/SC4/WG3 N756

5.3.11.1 Abstract

The objective of this example is to investigate how specifications belonging to different specification_category objects can be related to each other’s, and how a mechanism for inclusion of one specification object is managed.

5.3.11.2 User Description

In this simple but realistic and educational example 2 specification_category objects are presupposed. Namely 'Audio equipment' and 'Antenna'

The specifications within these categories are as follows...

Specification _category	Specification	Specification
Audio equipment	without audio	RADIO 1
Antenna	with antenna	without antenna

The customer is allowed to choose audio equipment without restrictions.

If RADIO 1 is chosen, then the specification 'with_antenna' must be included to the product specification.

In this example there are 3 cases to describe;

a) Antenna is allowed regardless of Audio equipment.

Here a AND-operation is used.

b) RADIO 1 implies that the specification 'Without Antenna' not is valid.

Here a NOT-operation is used.

c) If RADIO 1 is chosen, then the system must ensure that an antenna is mounted.

Here a specification_inclusion is used.

5.3.11.3 Mapping to the AP214 ARM

See EXPRESS-G instantiation diagrams as follows:

- Figure 5.3.11-1 Specification association page 152.
- Figure 5.3.11-2 Specification_expression page 153.

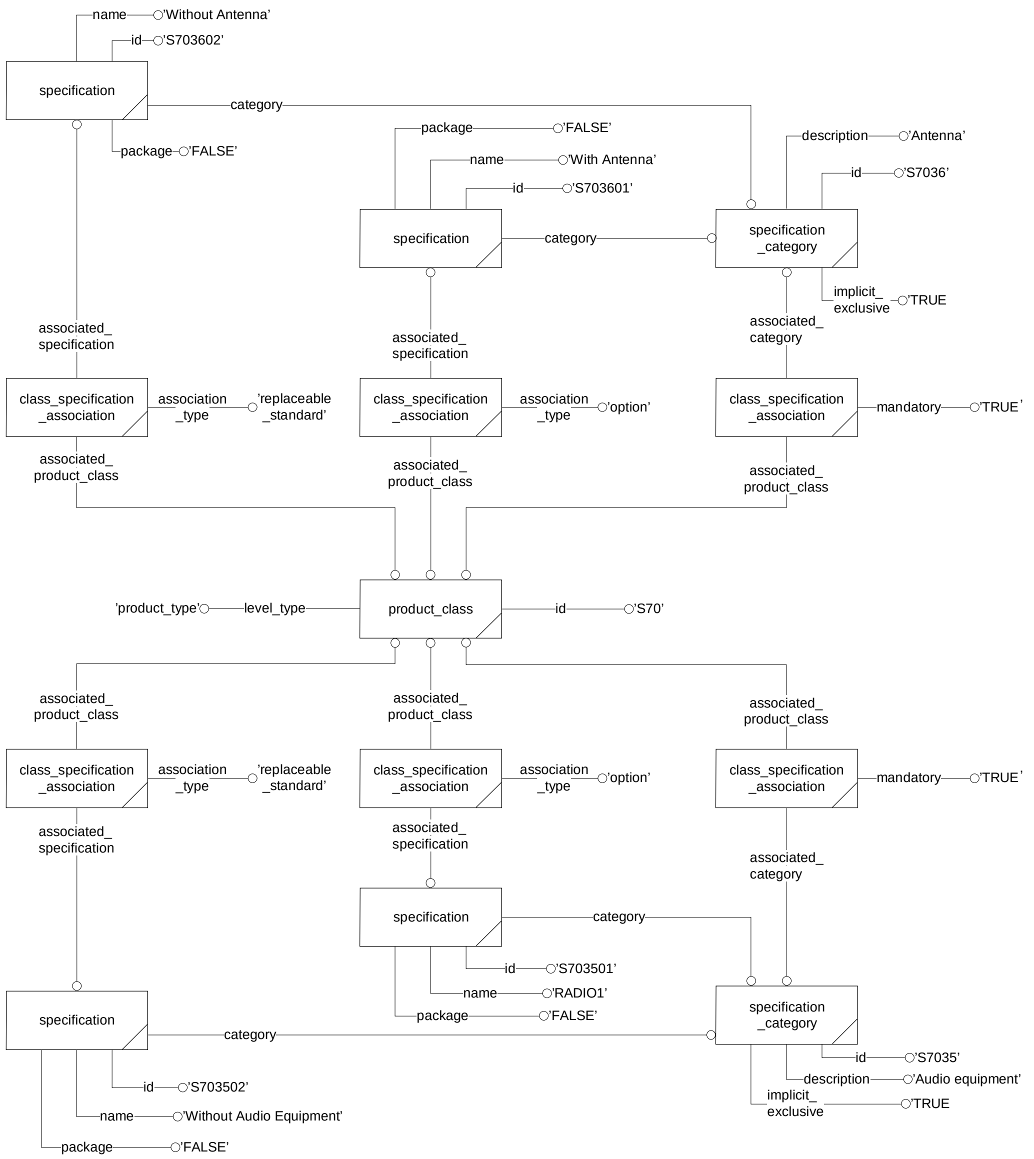


Figure 5.3.11-1 Specification association

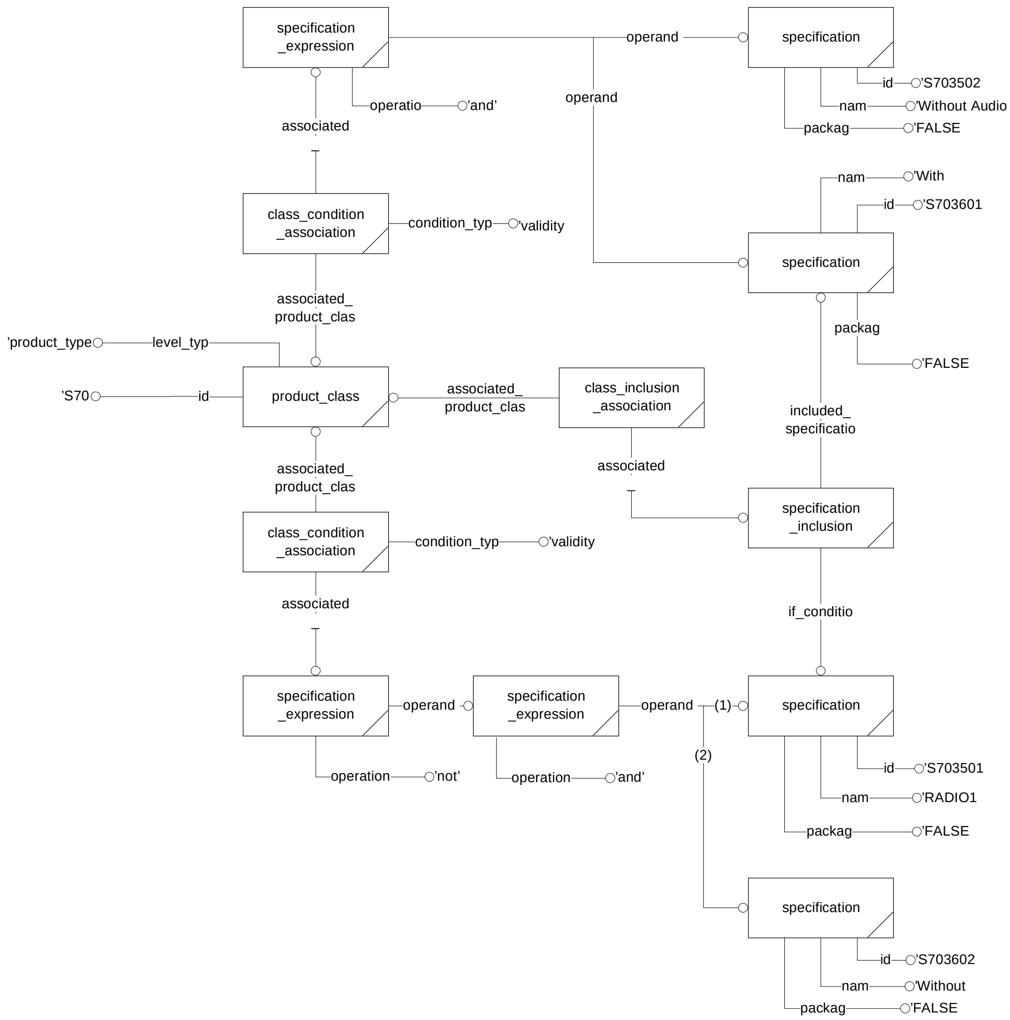


Figure 5.3.11-2 Specification_expression

5.3.11.4 Discussion

This model is adequate.

In the definition for the operation attribute of specification_expression is the usage of another specification_expression not included.

5.3.12 VW: Bill of Material of a VW Golf

Author: Gisela Schulze

Address: Volkswagen AG, Germany

Created: July 23, 1998

Reference document: ISO TC184/SC4/WG3 N756

5.3.12.1 Abstract

This example deals with a detail from the bill of material of a Volkswagen Golf; the detail contains the rear wheel brake, lh. There are two types of bill of material (BOM):

- the one-level assembly bill of material
- the multi-level structure bill of material.

5.3.12.2 User Description

In the enterprise Volkswagen AG, which consists of the brands Volkswagen, Audi, SEAT and Skoda, there are several levels of product classes. The highest level product class is used to define all PR-families (PR = primary property) and PR-numbers for all product classes of the enterprise. There are nearly 400 PR-families and 3000 PR-numbers available. Each low-level product class of VW enterprise has up to 200 PR-families assigned which are a subset of the PR-families of the high-level product class.

At the beginning of the development of a new car there are only text descriptions like performance specifications or standards and rules which have to be taken into account. Then a project and a development order will be defined, and some fundamental keys like product class, new PR-families or PR-numbers will be fixed. Later on, the PR-families and PR-numbers which are available for the product class will be assigned.

Tables 2.1 to 2.4 show details from the product description of a Volkswagen Golf (product class 1H0).

Table 2.1 shows four levels of product classes at Volkswagen.

product class	name	level
VW	Volkswagen enterprise	enterprise
A0	A0-class	platform
A	A-class	platform
1H0	Rabbit/Jetta	product family
A3	Audi A3	product family
1H13H5 X0A 1995	Rabbit syncro, market Germany, model year 1995	car type
1H13H5 X0A 1996	Rabbit syncro, market Germany, model year 1996	car type

Table 2.2 contains ten of the assigned 153 PR-families for the product class 1H0 and the information by which development order the assignment was done or becomes invalid.

PR-family	name	assigned product class	start definition	end definition
ASL	mirror, lh	1H0	EA100	
ASR	mirror, rh	1H0	EA100	
ATA	kind of drive	1H0	EA100	
AUS	equipment level	1H0	EA100	
BAH	type of rear brake	1H0	EA100	
BAV	type of front brake	1H0	EA100	
BRS	brake systems	1H0	EA100	
GSP	gearbox	1H0	EA100	
KAR	car body type	1H0	EA100	
MOT	engine	1H0	EA100	

Table 2.3 contains for three of these PR-families the PR-numbers which are valid for the product class Golf.

PR-family	PR-number	name	product class	start definition	end definition
KAR	K8B	Notch-back sedan	1H0	EA100	
KAR	K8D	Variant	1H0	EA101	
KAR	K8G	Short-back	1H0	EA100	
BAH	1KB	reinforced drum brake, version 1	1H0	EA100	
BAH	1KC	reinforced drum brake, version 2	1H0	EA100	
BAH	1KM	reinforced drum brake, version 3	1H0	EA100	
BRS	1AB	brake Servo unit	1H0	EA100	
BRS	1AC	anti-locking brake system (ABS)	1H0	EA100	
BRS	1AE	anti-block system (ABS) and electronically differential lock (EDS)	1H0	A95005	
BRS	1AG	brake Servo unit, 9 inch	1H0	EA100	

Table 2.4 contains the subset of PR-numbers of the Golf which is relevant for product class 1H13H5 X0A 1995. It also contains the information whether a certain PR-number identifies the product class, is a non-replaceable standard, a replaceable standard or an option for that product class.

PR-family	PR-number	name	product class	type
KAR	K8G	Short-back	1H13H5 X0A 1995	identifying
BAH	1KC	reinforced drum brake, version 2	1H13H5 X0A 1995	non-replaceable standard
BRS	1AC	anti-locking brake system (ABS)	1H13H5 X0A 1995	replaceable standard
BRS	1AE	anti-block system (ABS) and electronically differential lock (EDS)	1H13H5 X0A 1995	option

The mapping of this information to AP214 is shown in figures 6 to 9.

Figure 1 gives an overview of the example which will be discussed in detail in figures 2 to 5. At Volkswagen there are two types of bill of material:

- the one-level assembly bill of material.

  In this BOM, each assembly is defined exactly once; items which perform similar functions and consist of the same number of components are assigned to an assembly node. The components of the items also are assigned to nodes depending on the function of the component in the assembly. There is no reference to a product class with the meaning ‘this product class is decomposed by these nodes’.

- the multi-level structure bill of material.

  The entry of this BOM is a product node (a car, an engine, a gearbox etc.). This product node is decomposed by structure nodes (up to 15 levels). Each structure node can be realised by one or more variants. Each structure node in the multi-level structure BOM may refer to one or more assembly nodes in the assembly BOM (e.g. structure node ‘rear wheel brake, lh’ refers to assembly nodes ‘drum brake’ and ‘disk brake’; both of these assembly nodes can be used as rear wheel brake but their sub-functions are totally different).

Figures 2 and 3 contain a detail from the BOM which will be used to give instructions to the engineers. In many cases a new car will not be totally new but a new generation of an existing car. Even if it is a totally new one, the car will have many well known components. So most of the structure nodes can be copied from an existing product class to the new one (e.g. front axle, rear axle, bumper, mirror lh, mirror rh, engine, gearbox, radio, steering wheel etc.). **Figure 2** shows a detail from a structure BOM which only consists of a product node, structure nodes and relationships between those nodes.

Figure 10 is showing the mapping of this information.

Figure 3 shows the information assigned to a structure node (e.g. rear wheel brake, lh) or to a variant:

- the PR-families the structure node is influenced by
- the number of variants to be developed
- the documents which should be taken into account
- the cost target for each variant of the node
- the weight target for each variant of the node
- the date when a certain approval status should be reached

  etc.

So the engineer who has to develop the alternatives of rear wheel brake lh gets all information which is necessary to do his work.

The mapping is shown on **Figures 11 and 12**.

Figure 4 shows the first steps to do in the BOM (some nodes are omitted):

- look for an existing assembly node ‘drum brake’ in the assembly BOM (in this example the PR-family ‘type of rear brake’ only contains PR-numbers for drum brakes)
- if there is no assembly node ‘drum brake’, define a new one
- define the assembly (part) structure according to the structure of the assembly node
- link the assembly nodes to corresponding structure nodes
- link the parts to variants in the structure BOM

The mapping is shown on **Figures 13 to 16**.

Figure 5 shows the assembly structure of five alternatives of drum brake which are linked to some variants in the structure BOM. For each variant a „TEGUE“ (German term: Teilegueltigkeit, short: TEGUE) contains the condition which controls the usage of the variant in a product. The meaning of ‘1H0 +1AB/1AG+1KB’ is:

variant 1 is used in all products of product class 1H0 which have either brake Servo unit or brake Servo unit, 9 inch AND reinforced drum brake, version 1.

The mapping of TEGUE is shown on **Figure 17**.

Some of the information described above is valid during a certain period of time only. At Volkswagen, the periods of time in the bill of material are not defined by explicit dates but by timing keys. These timing keys are managed in a special system. A timing key that controls the development of a product class is differentiated for each plant in which products of the product class will be produced, and for each PR-number that is valid in the plant. Furthermore, there are dates for pre-series and series production (nominal and actual dates).

Example:

timing key	product class	plant	PR-number	date pre-series	date series
EA100	1H0	Wolfsburg	K8G	10.03.1993	01.06.1993
EA100	1H0	Mosel	K8G	03.05.1993	15.09.1993

The meaning of this information is:

- pre-series for Golf, Short-back started in Wolfsburg on 10.03.1993, series production started on 01.06.1993
- pre-series for Golf, Short-back started in Mosel on 03.05.1993, series production started on 15.09.1993

The mapping of timing keys and the assignment to some piece of product data is shown on **Figures 18 to 20**.

Figure 1: Detail from the bill of material of a Volkswagen Golf

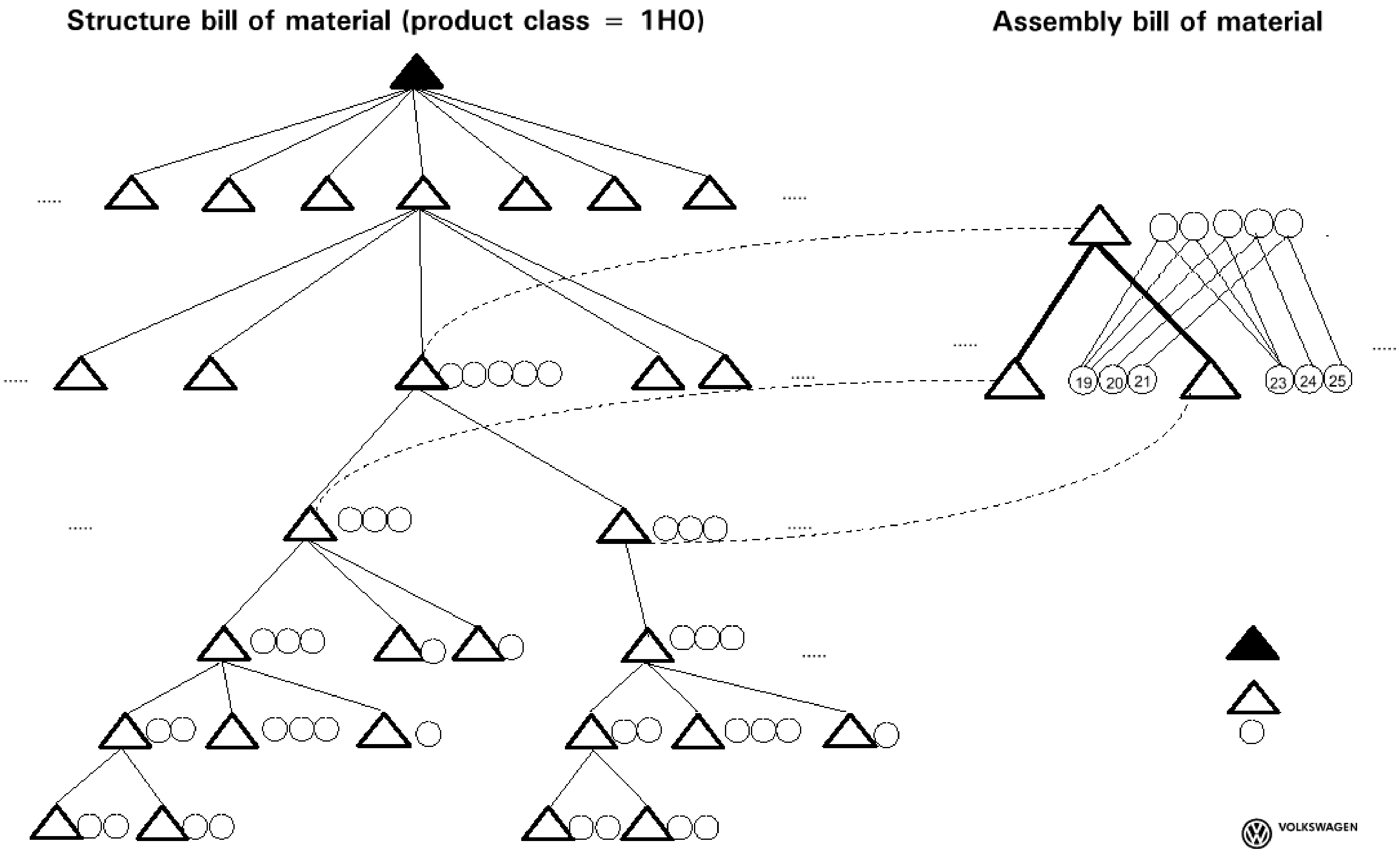


Figure 2: Detail from the bill of material of a Volkswagen Golf

Usage of structure nodes to give instructions to the engineer
Structure bill of material, structure nodes without parts

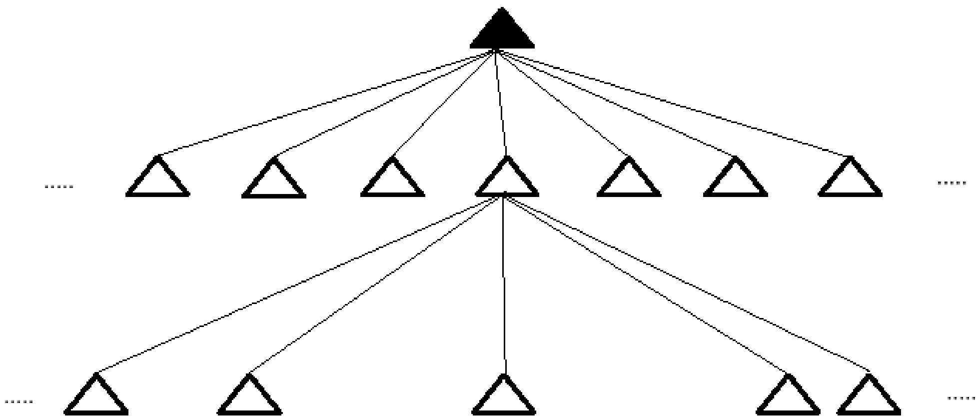


Figure 3: Detail from the bill of material of a Volkswagen Golf

Usage of structure nodes to give instructions to the engineer

Selection of a node (here: rear wheel brake, lh)

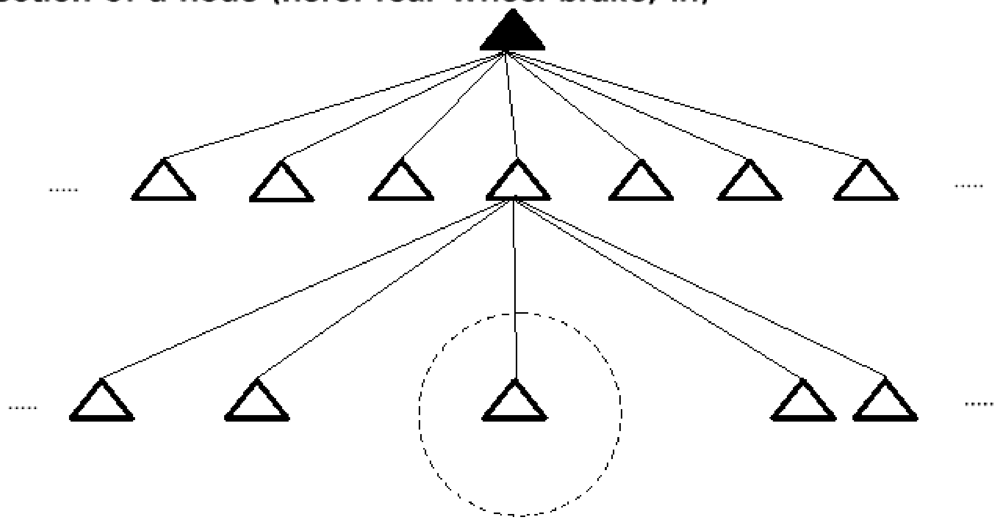
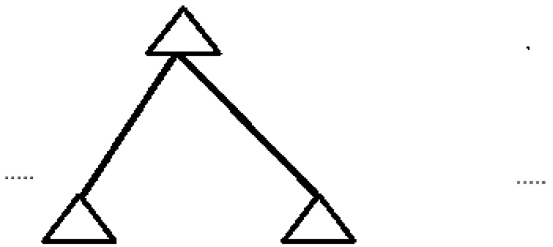


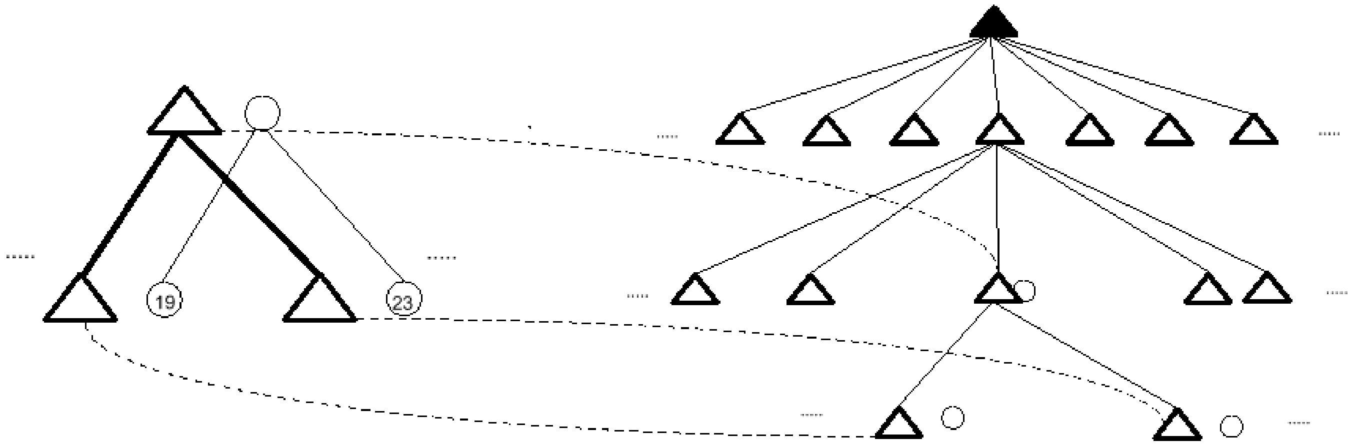
Figure 4: Detail from the bill of material of a Volkswagen Golf

Development of a variant for the rear wheel brake, lh

First step: Definition of assembly nodes



Second step: Definition of the assembly structure and link to the structure bill of material



VOLKSWAGEN

Figure 5: Detail from the bill of material of a Volkswagen Golf

Third step: Definition of further variants for the rear wheel brake, lh (assembly structure and link to the structure bill of material)

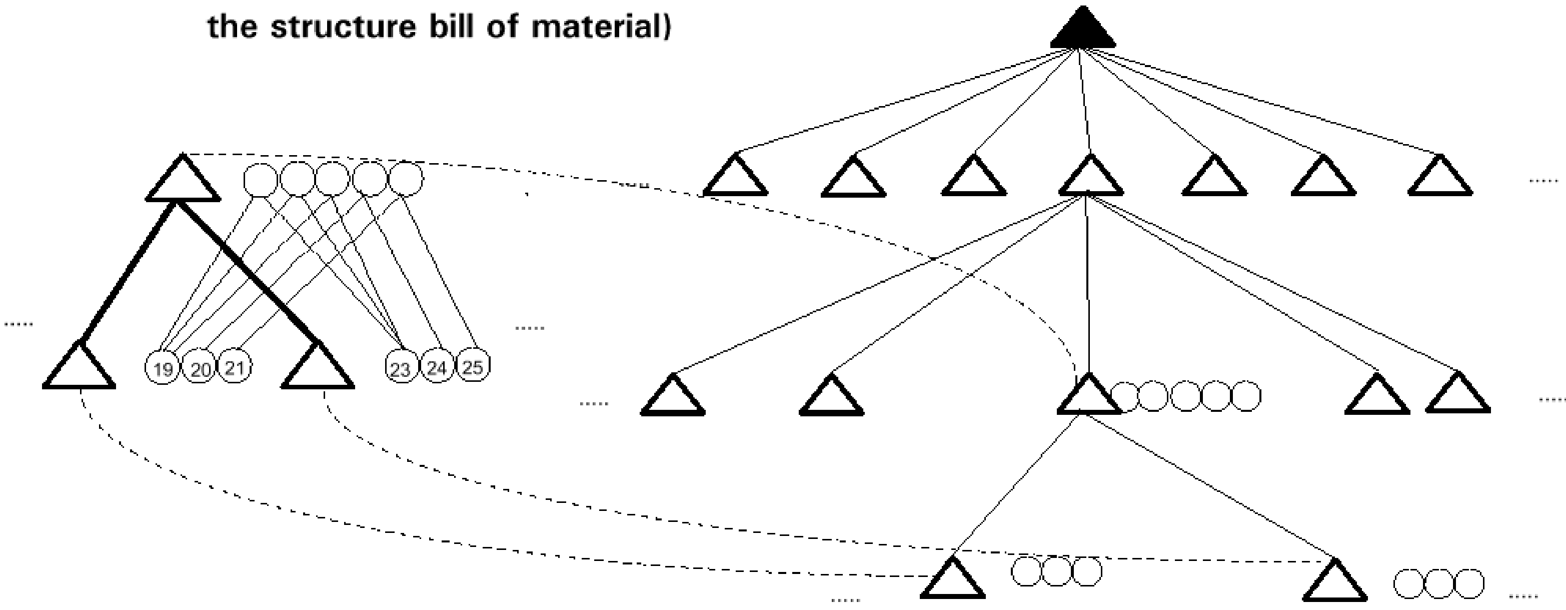


Figure 6: Detail from the bill of material of a Volkswagen Golf

Fourth step: Definition of further assembly nodes and variants down to the single part level

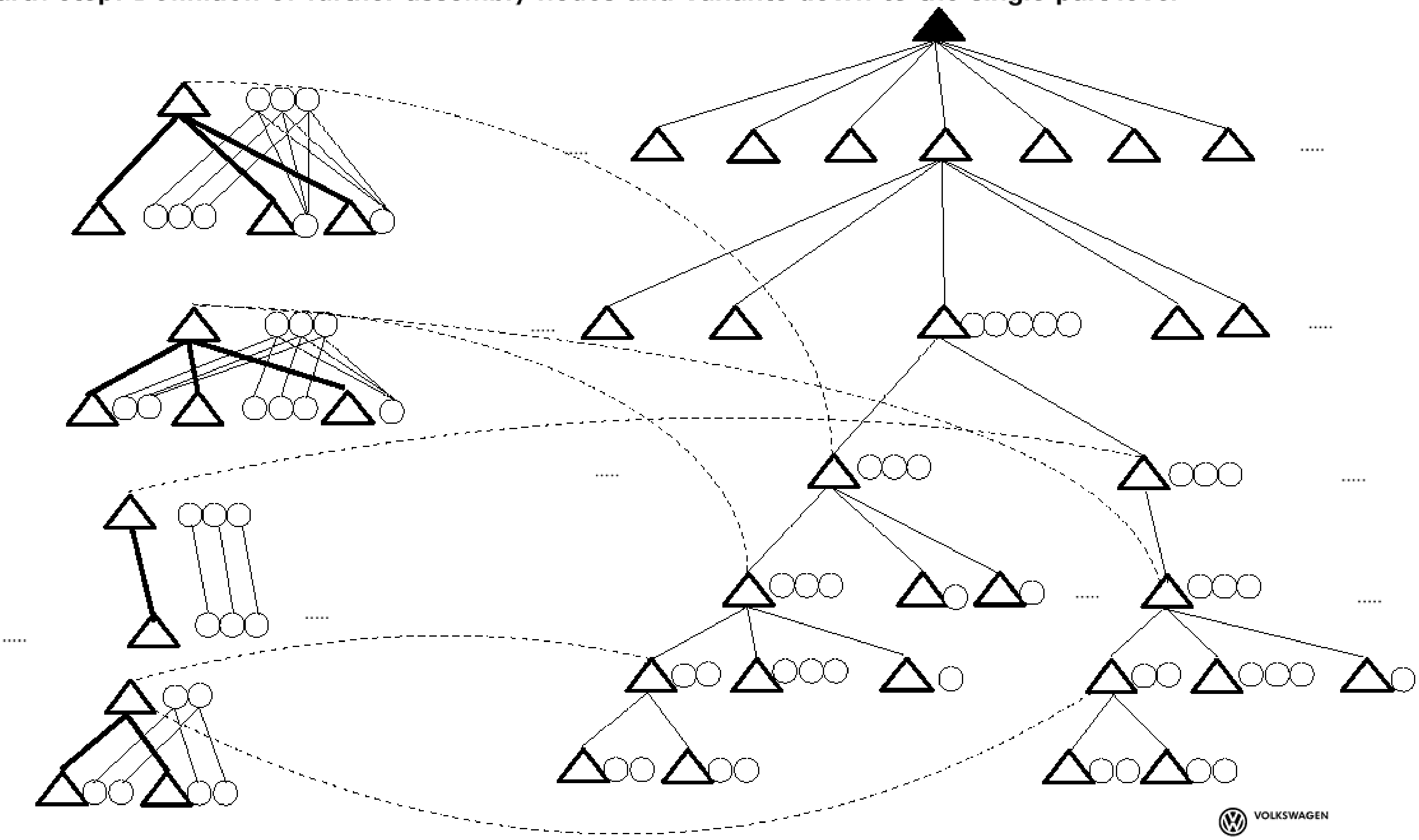


Figure 6: Mapping of Product_class objects

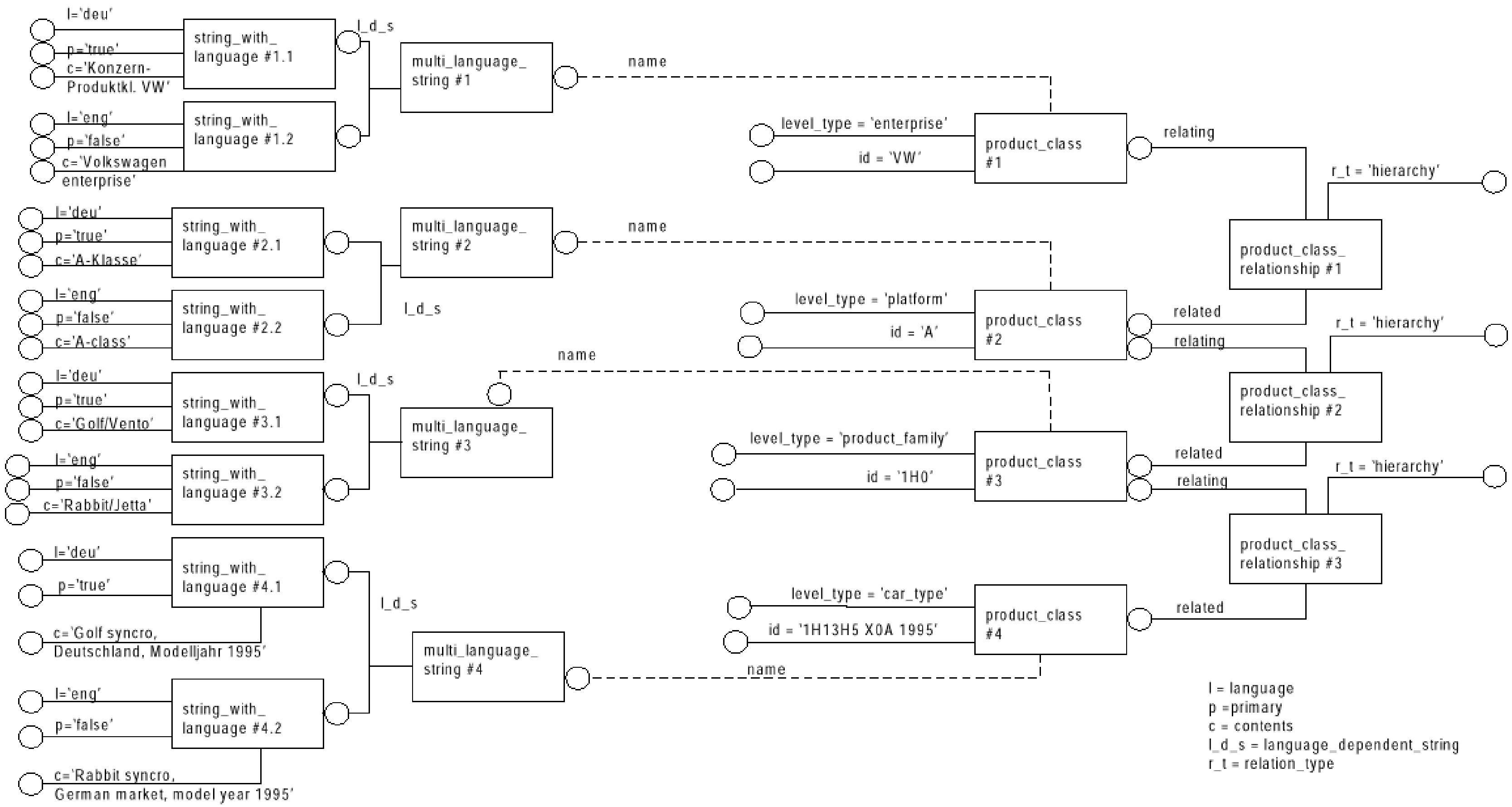


Figure 7: Mapping of Product_class, Specification_category and Specification objects

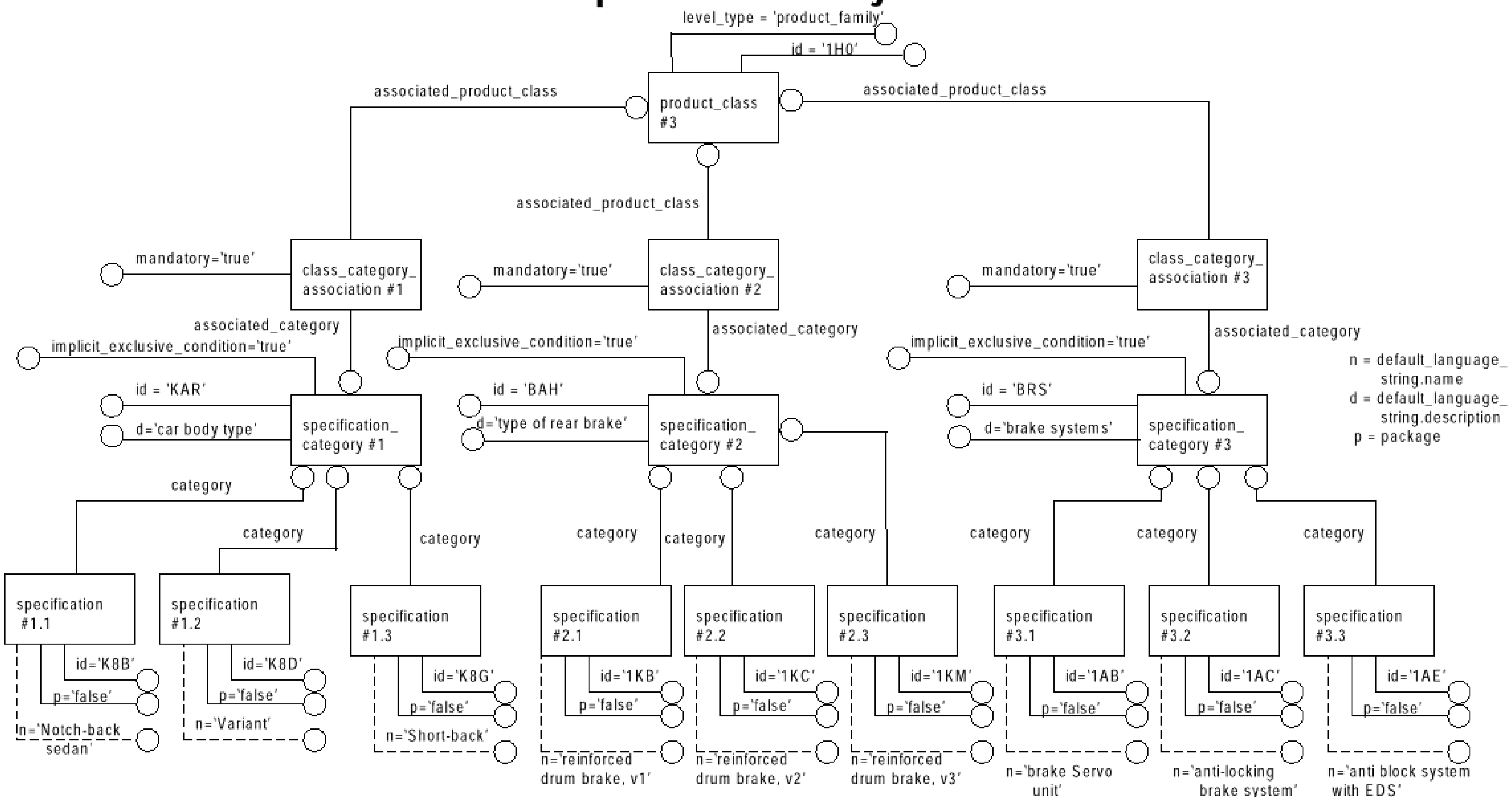


Figure 8: Mapping of Product_class and Specification objects

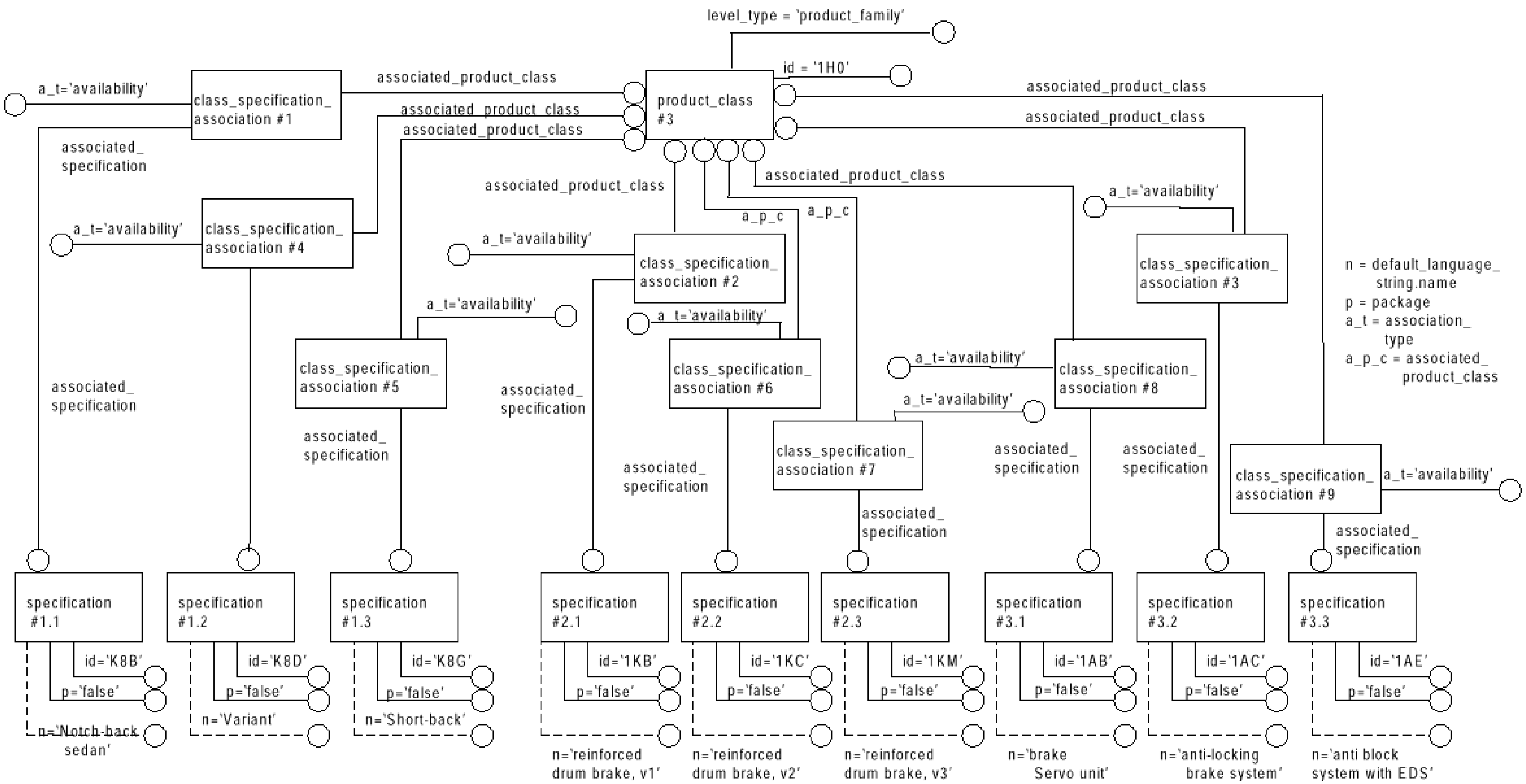


Figure 9: Mapping of Product_class and Specification objects

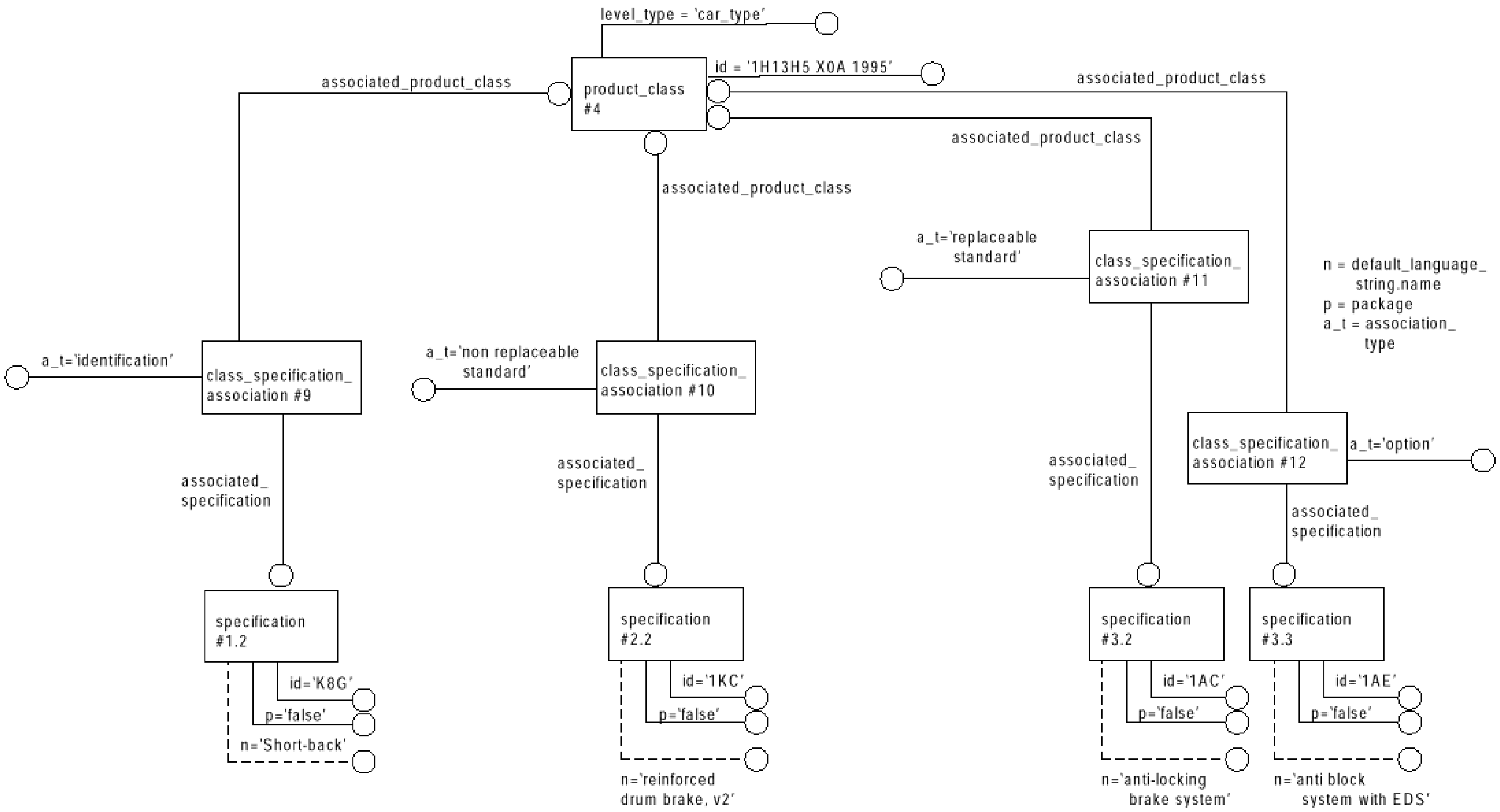


Figure 10: Mapping of Product_component objects (structure bill of material)

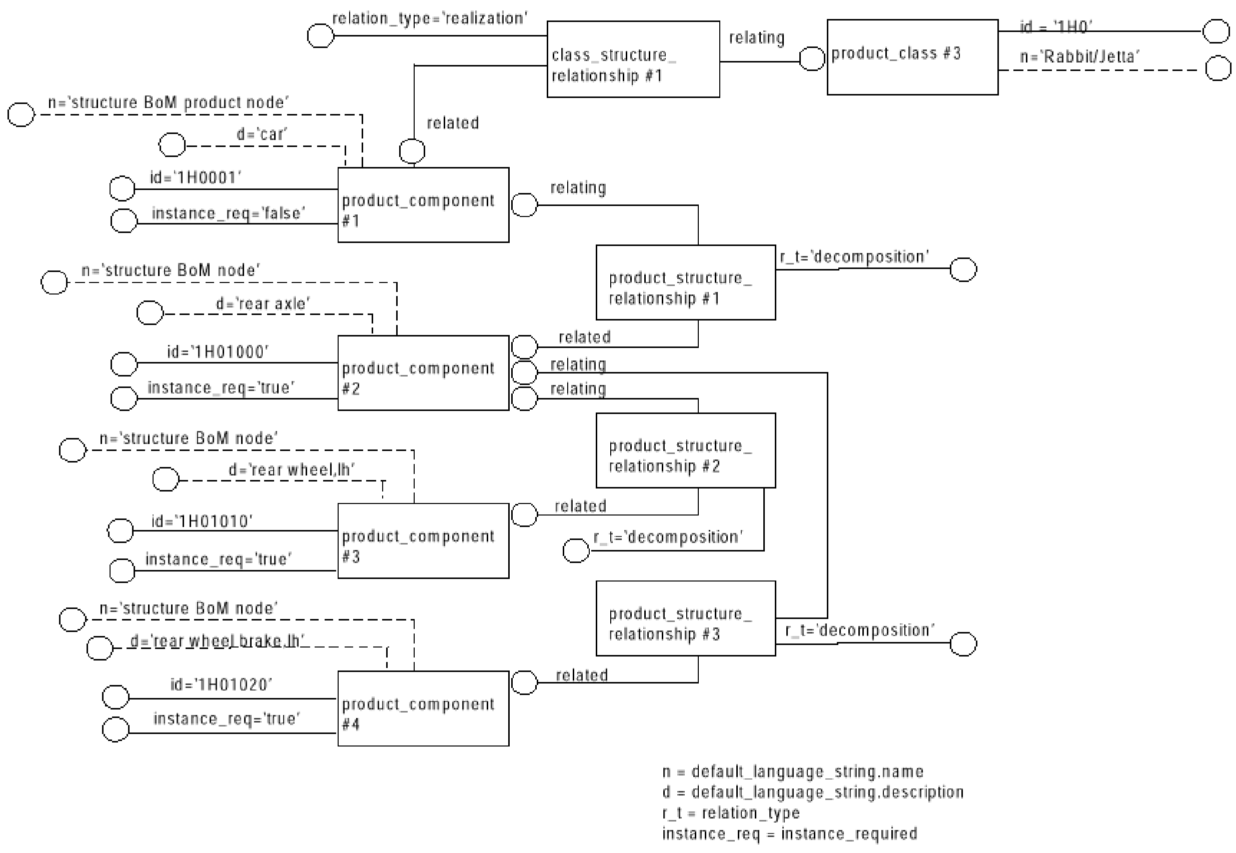


Figure 11: Mapping of a Product_component (1)

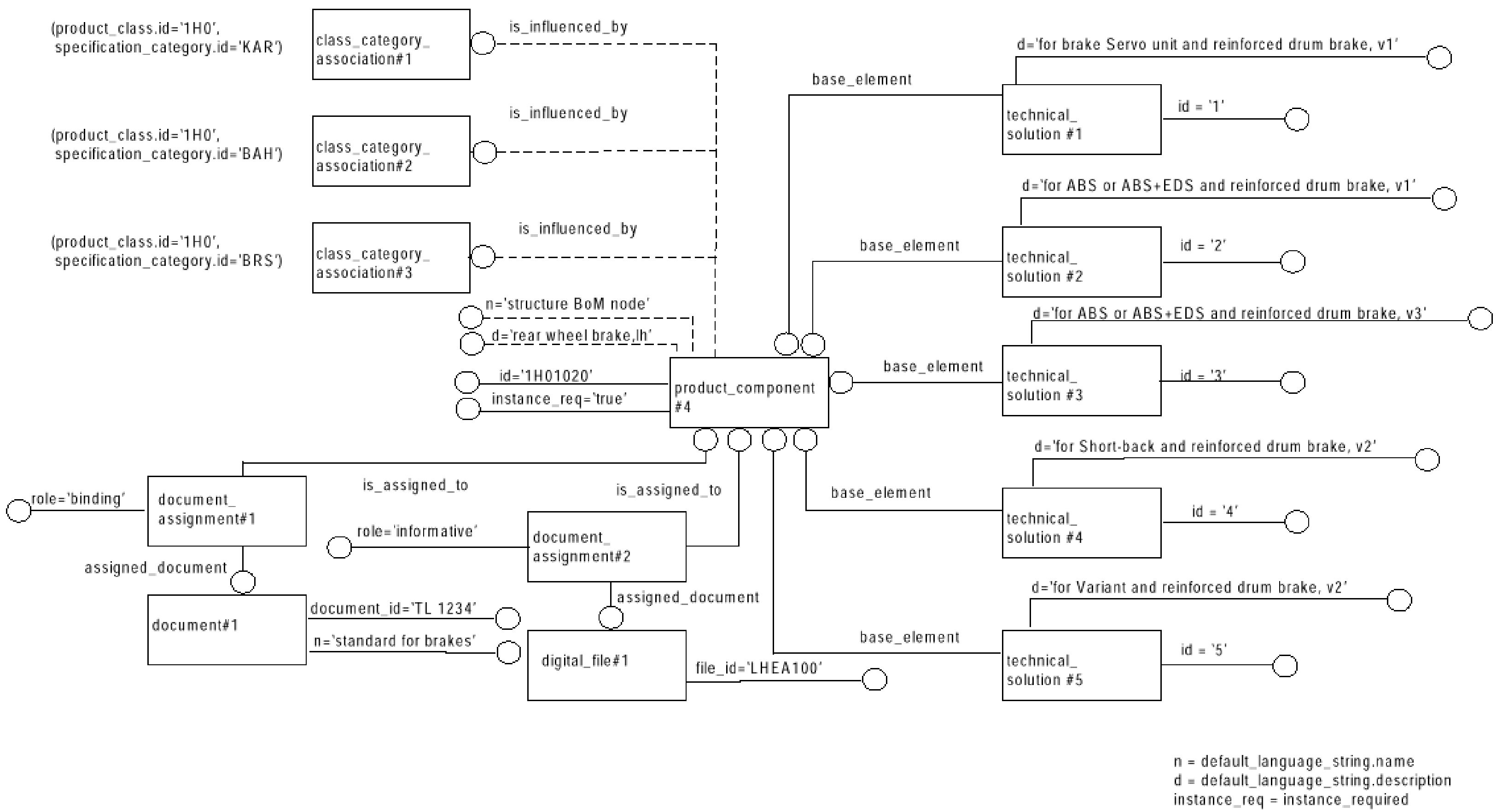


Figure 12: Mapping of a Product_component (2)

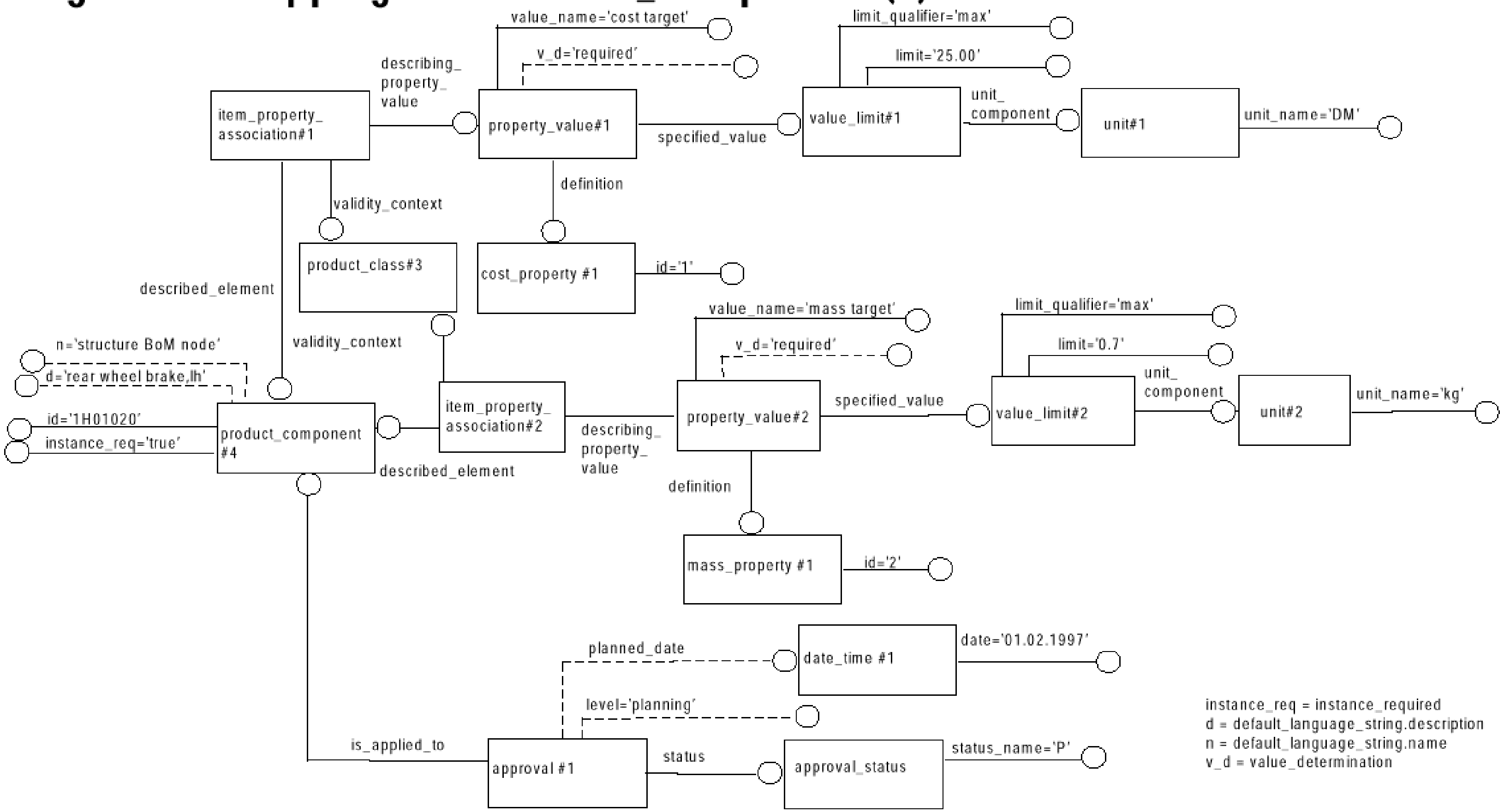


Figure 13: Mapping of Product_component objects (assembly bill of material)

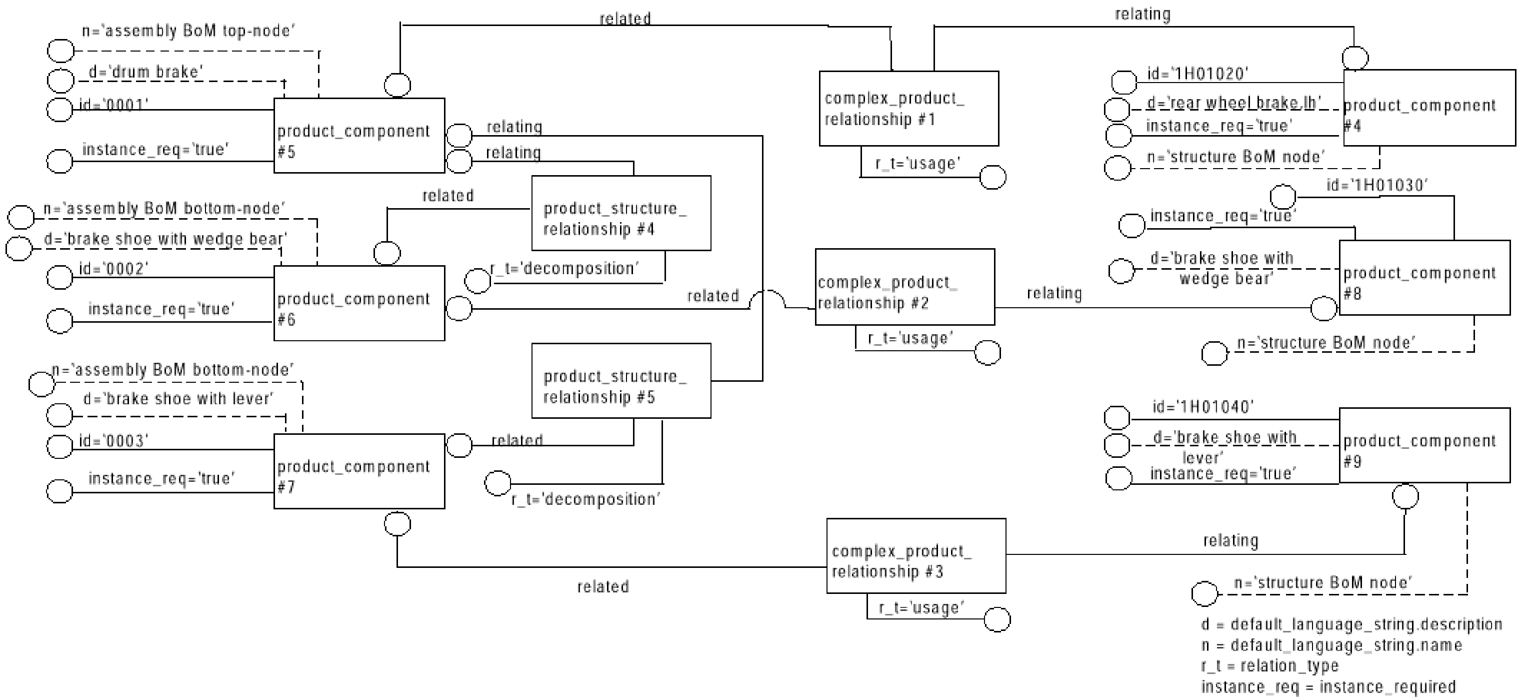
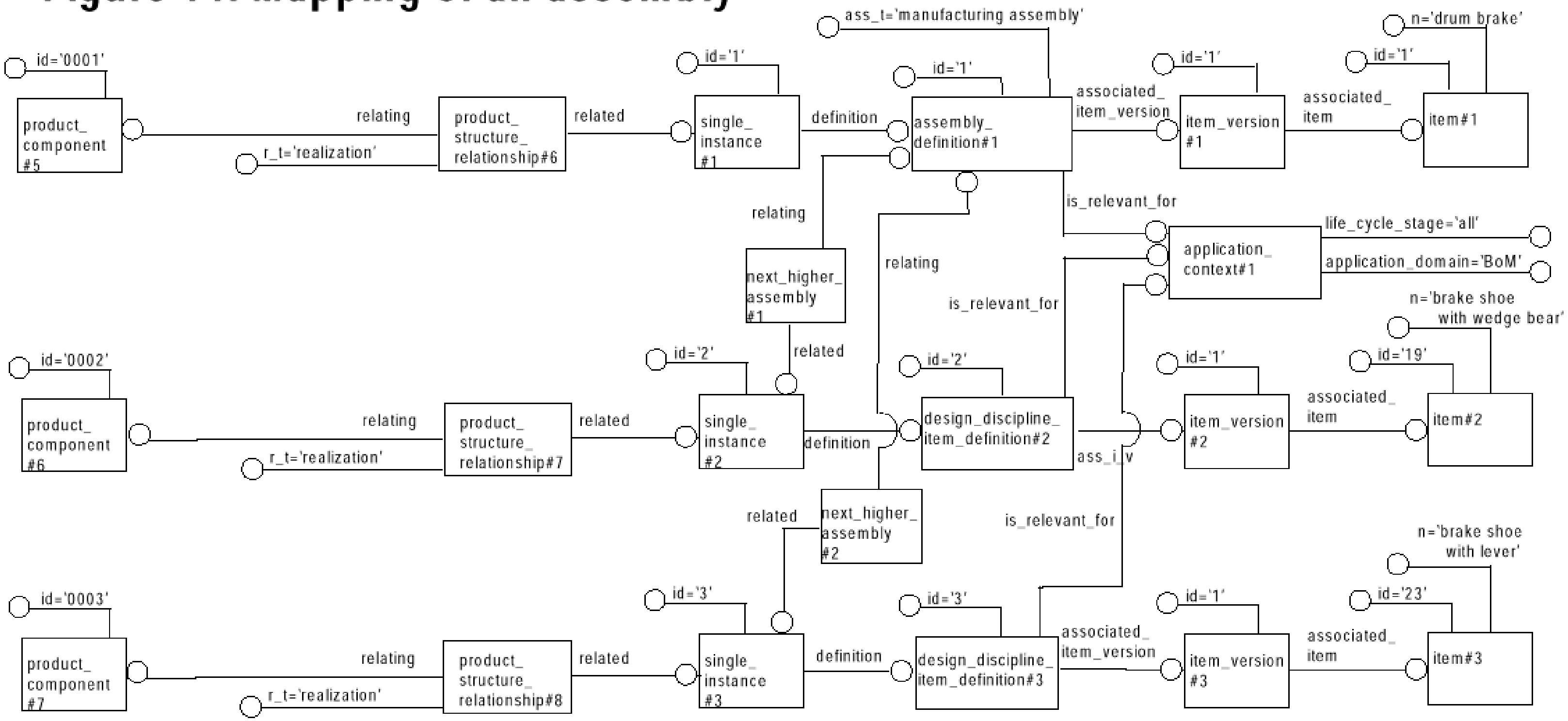


Figure 14: Mapping of an assembly



ass_i_v = associated_item_version
ass_t = assembly_type
n = default_language_string.name
r_t = relation_type

Figure 15: Mapping of an Item object

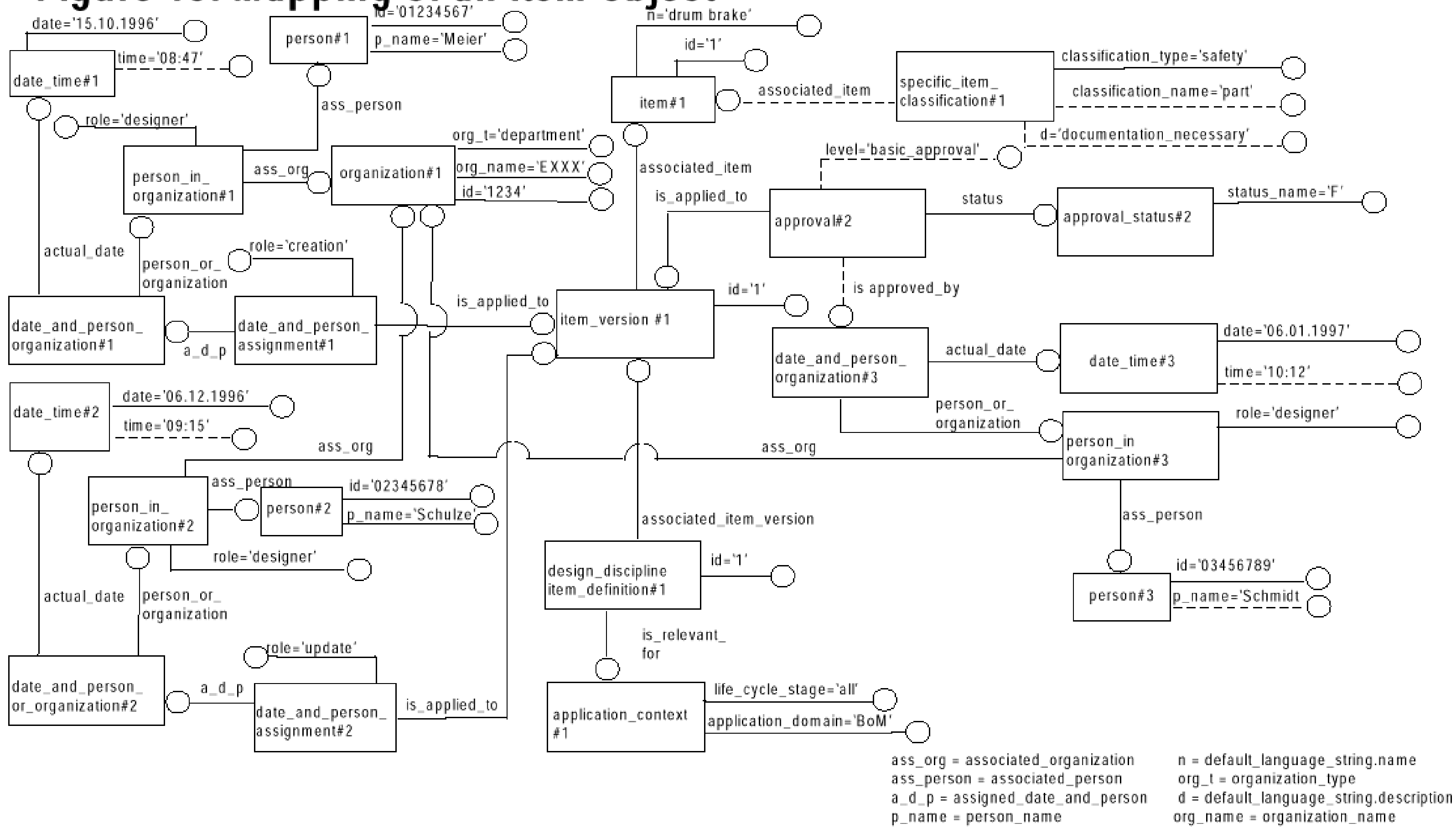


Figure 16: Mapping of Item objects in the structure bill of material

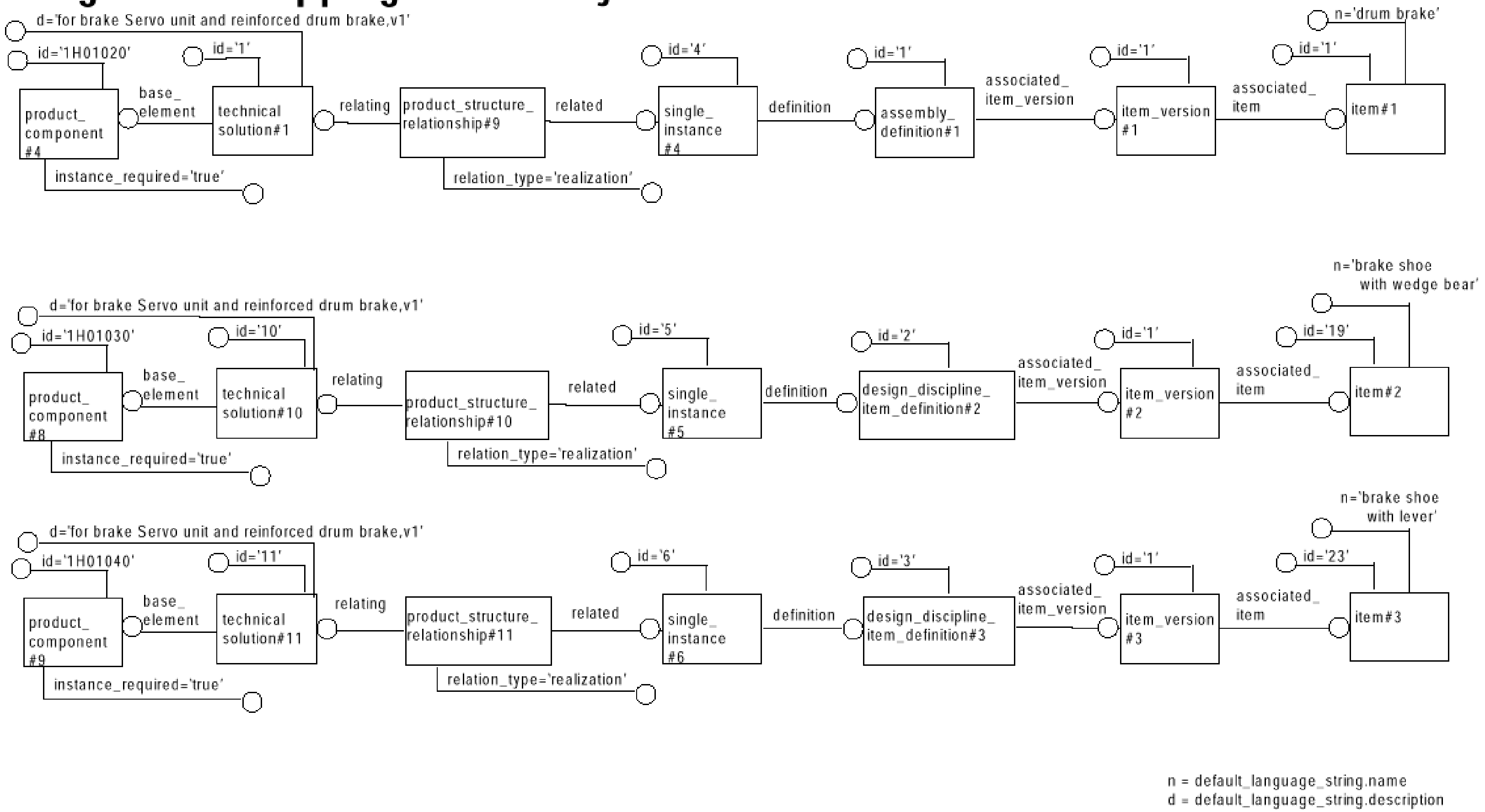


Figure 17: Mapping of Specification_expression and Specification_inclusion objects

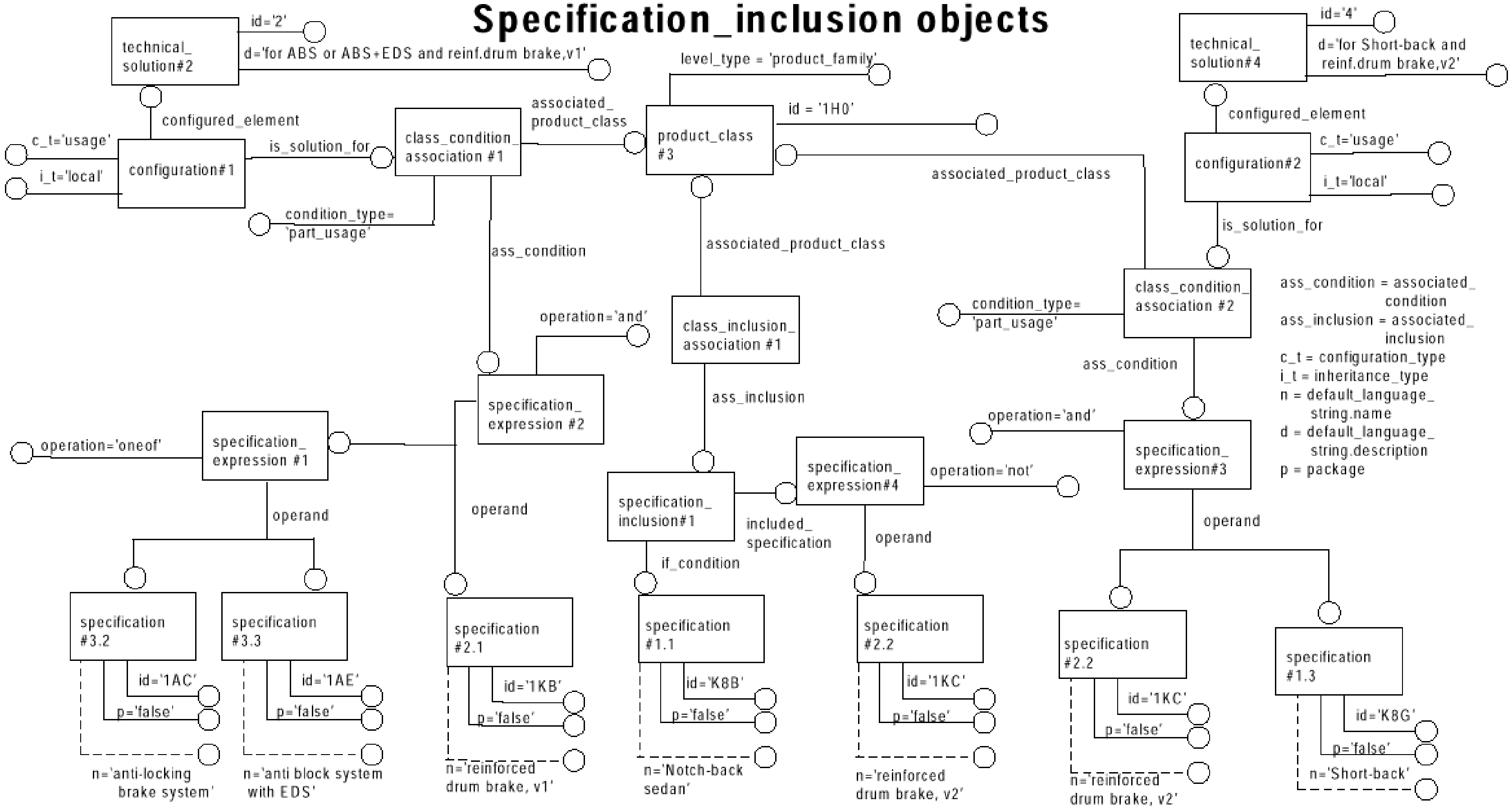


Figure 18: Mapping of Project and Activity objects

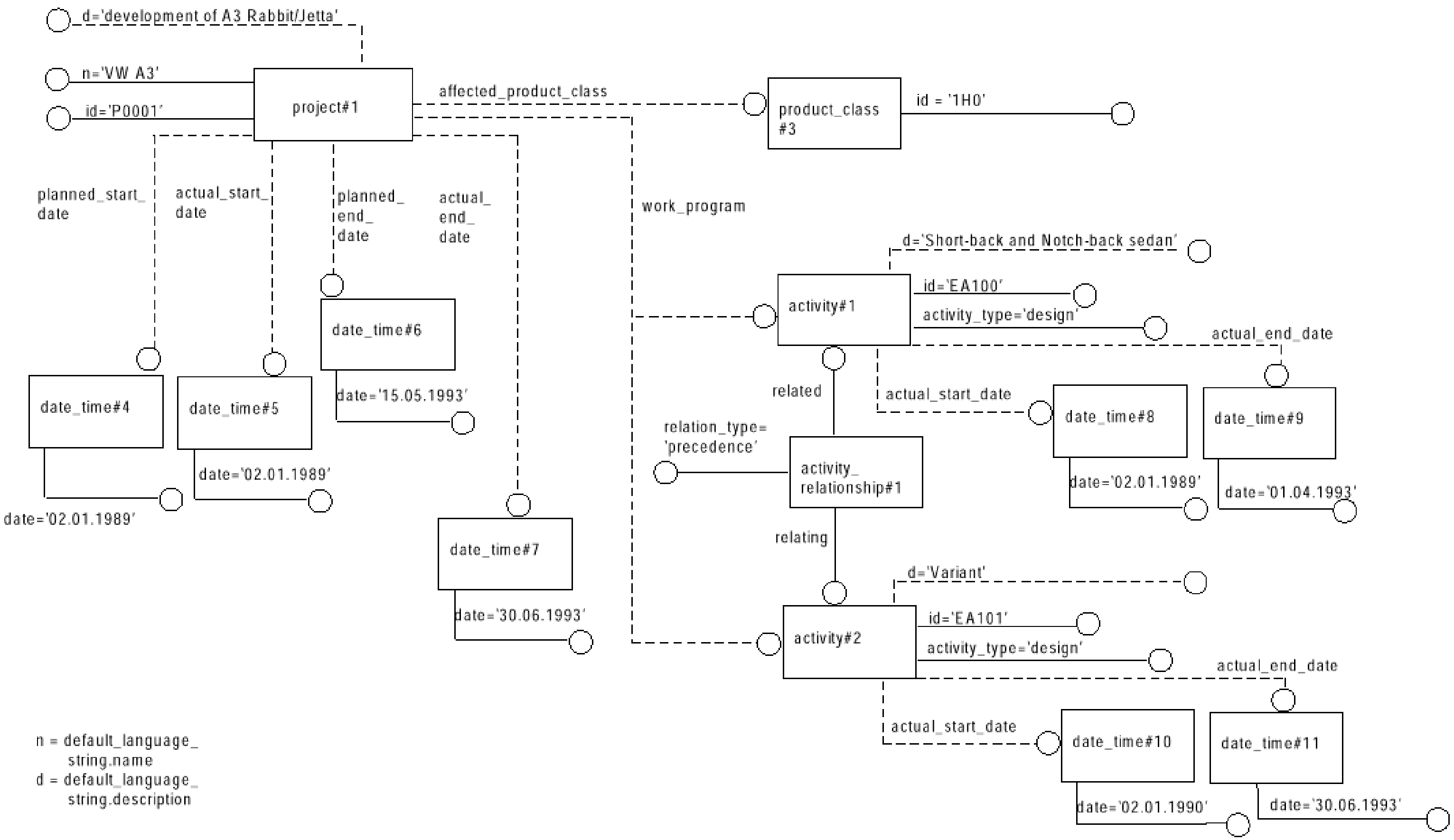
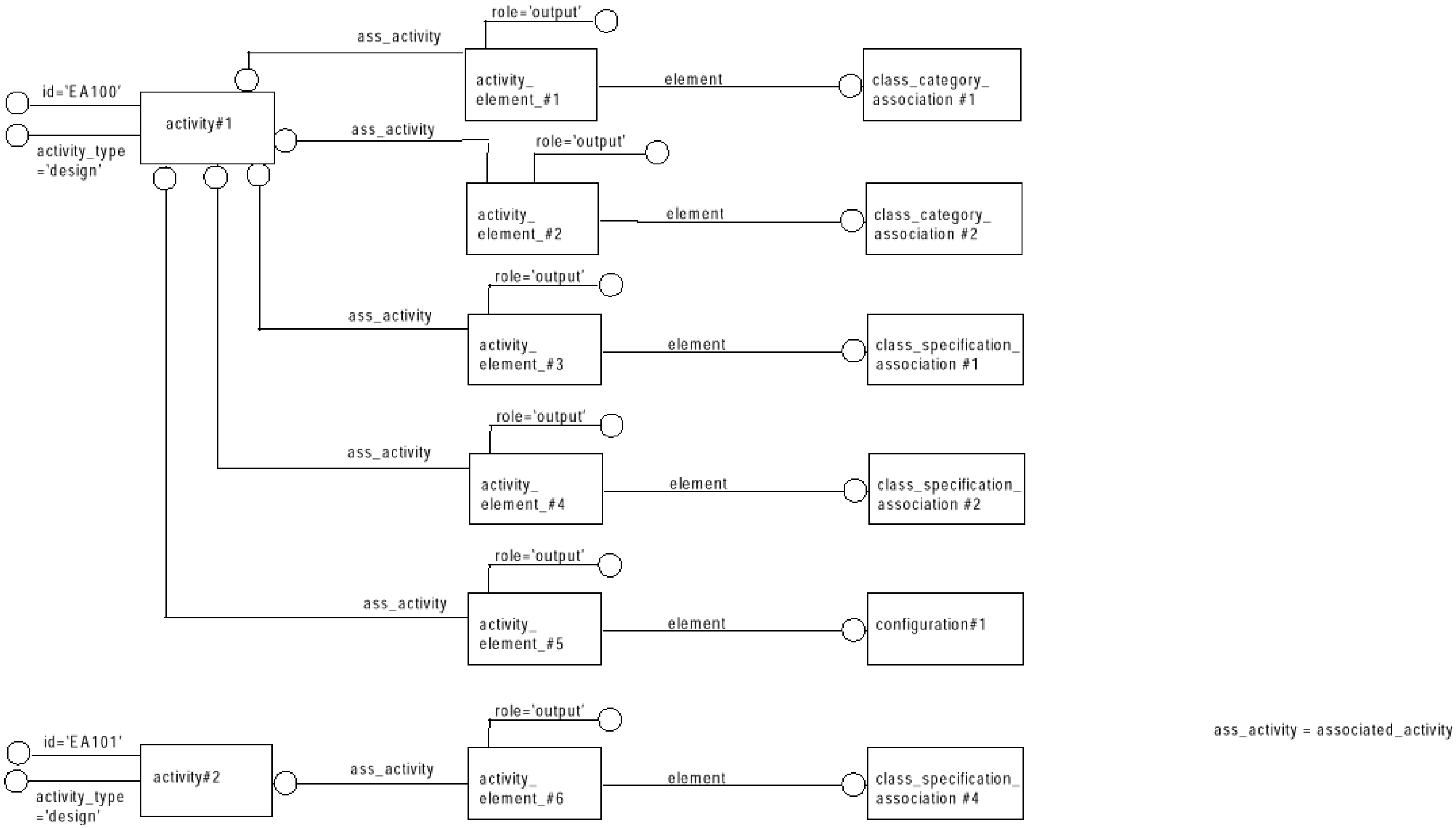


Figure 19: Mapping of Activity_element objects



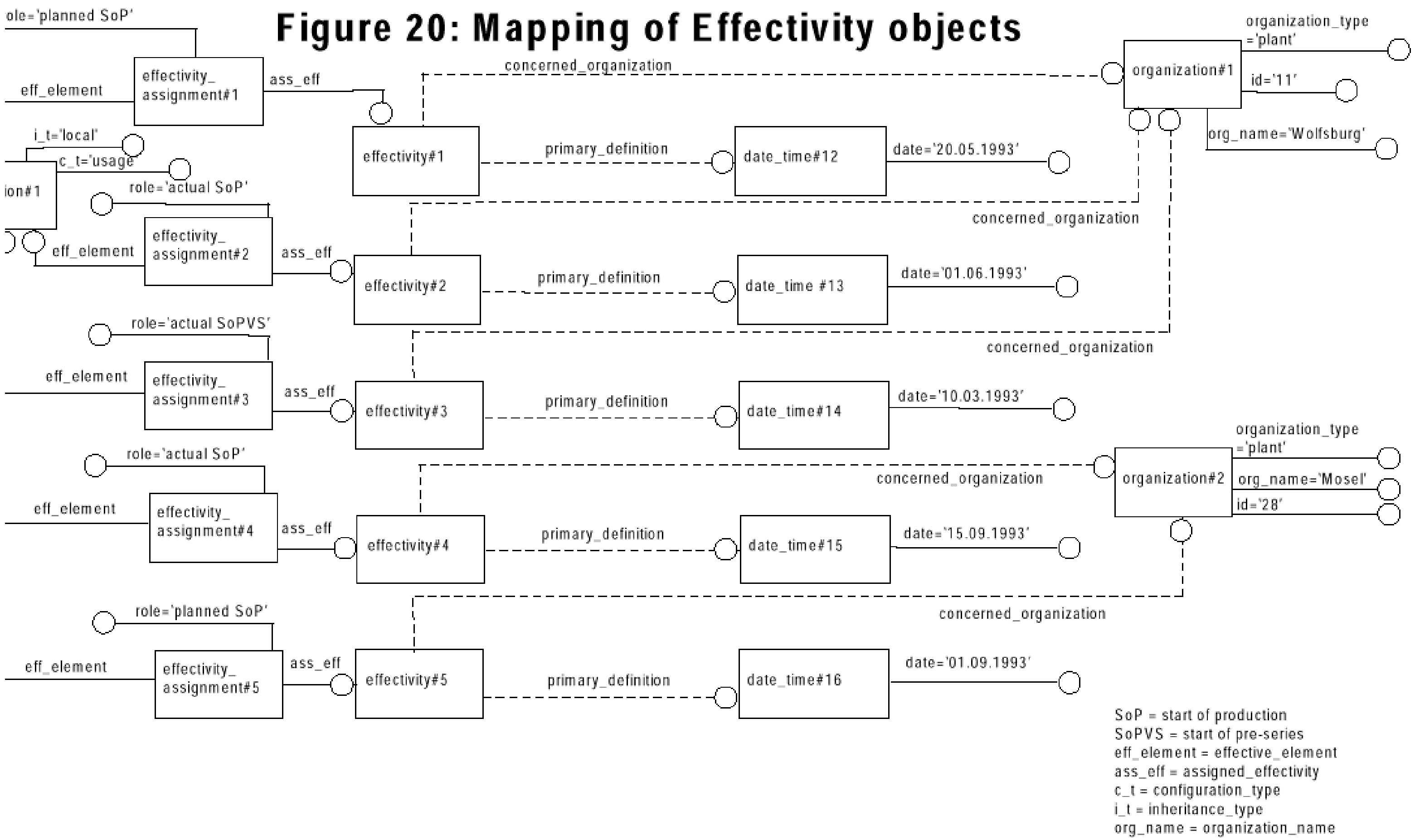


Figure 20: Mapping of Effectivity objects

5.3.12.3 Mapping to the AP214 ARM

Table 3.1 Terminology of application experts

terminology of application experts	example	AP214 application object
approval status	P (approved for planning purposes), D (approved for disposition)	approval_status
assembly node	drum brake	product_component
development order		activity
part		item
PR-family	car body type, level of equipment	specification_category
PR-number	hatchback, limousine	specification
product class	Golf, A6, Octavia, Arosa	product_class
product node	car	product_component
project		project
relationship between nodes		product_structure_relationship, complex_product_relationship
structure node	rear wheel brake, lh	product_component
TEGUE	1H0 +1AB/1AG+1KB	specification_expression, class_condition_association
timing key	EA100	activity
variant		item_solution

5.3.12.4 Discussion

The population of the structures of the AP214 ARM with the data of the example showed that the requirements of this example are very well met.

5.3.13 VW: Front Hood of VW Passat (Methods Development)

Owner: Dr. Ridwan Sartiono, Volkswagen AG, Germany

Date: September 23, 1993

Referenced document: ISO TC184/SC4/WG3/N536

5.3.13.1 Abstract

This example deals with the design of the front hood of a Volkswagen Passat. The front hood is a sheet metal part designed by using a 3D surface modeling CAD system. The design is used as input to create a methods plan which describes the manufacturing steps necessary to produce the sheet metal part.

5.3.13.2 User description

The car body is an assembly and consists of constituents like front hood, door or rear hood. The front hood is an assembly itself and consists of the constituents outside panel, inside panel, hinge, etc. as shown in Figure 5.3.13-1. This example describes the activity 'methods development' (node A221 of the AAM) for the component outside panel. With regard to the data handled in this subprocess, emphasis is put on process plan data, product management data and assembly structure data.

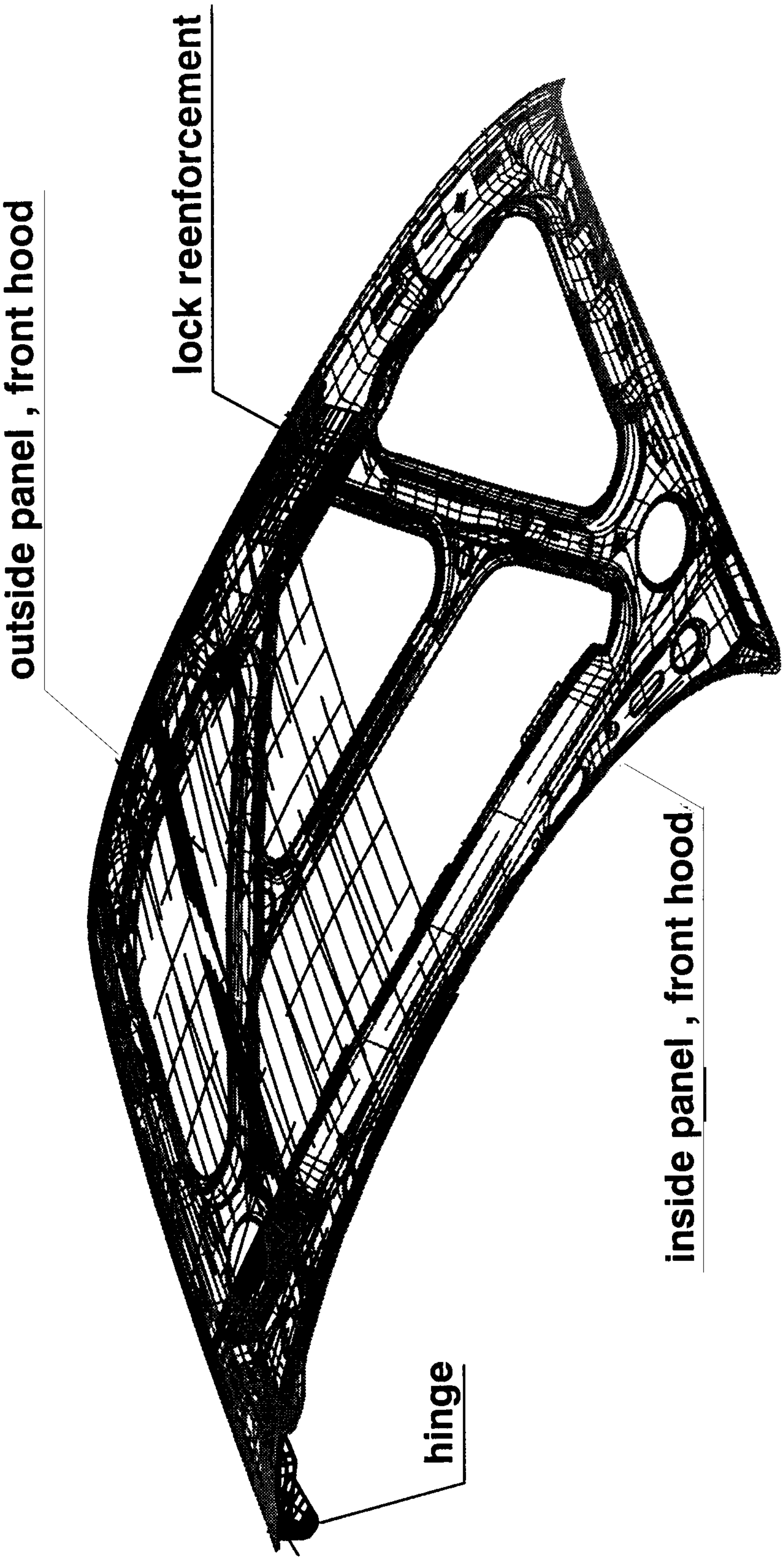


Figure 5.3.13-1: Front hood of a VW Passat

In the initial state of the process, the design department defines the geometric shape of the outside panel and the inside panel using the 3D-surface modeling CAD-system ICEM-DDN. Output of this activity is a 3D-surface model and a technical drawing with explicit dimensioning for each component. The created product data are stored in the company database together with organizational information such as part identification, creator of the product data, approval information, etc. These data are used as input for the activity 'methods development' (node A221 of the AAM).

The methods development department takes the design information as input for the 3D CAD system CATIA. From these data the methods plan and the fold plan for the manufacturing of the outside panel in several process operations (German term: "Arbeitsfolge", short: "AFO") are derived. For each AFO, a 3D-surface model is created which represents the so-called in-process-part. These surface models are included in a technical drawing representing the methods plan as partially shown in Figure 5.3.13-2.

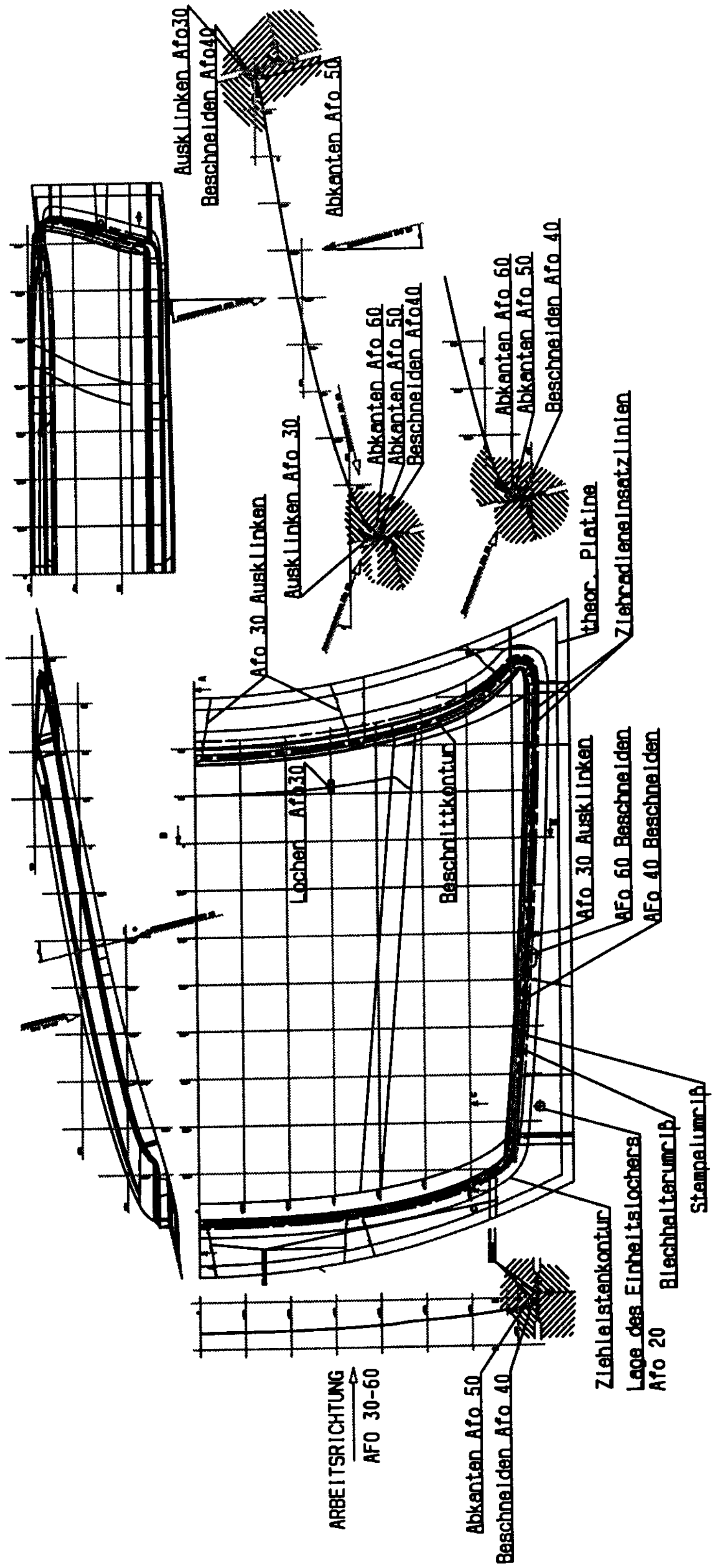


Figure 5.3.13-2: Technical drawing representing the methods plan of the outside panel

For each process operation (AFO) a corresponding tool is assigned together with an operation description. This information is also represented on the methods plan. Figure 5.3.13-3 gives an example of the representation of this information for the AFOs concerning the outside panel.

	methods plan		
part position	**operation**	**AFO**	**tool id**
	sheet metal cutting	10	14-72-D-108100
	drawing draw part, punch 2 standard holes	20	drawing tool 14-72-D-18721
drawing position turned 180°	trimming, punching draw part, punch 2 rectangle holes	30	trimming tool 14-72-D-18722
same as AFO 30	trimming	40	trimming tool 14-72-D-18723
same as AFO 30	bending	50	bending tool 14-72-D-18724
same as AFO 30	bending	60	bending tool 14-72-D-18725

Figure 5.3.13-3: Representation of process operation information for the outside panel

After this sequence of process operations (AFO10 - AFO60) special operations accour where the outside panel and the inside panel are folded together (AFO65 - AFO80). These folding operations are represented on a separate technical drawing, the fold plan (see Figure 5.3.13-4). The subsequent process operations (AFO) are described as follows:

- AFO65: fitting (of outside panel and inside panel)
- AFO70: prefolding
- AFO80: final folding

Therefore AFO65 is a special process operation having two input parts, the outside panel and the inside panel. The complete structure of the example is shown in Figure 5.3.13-5.

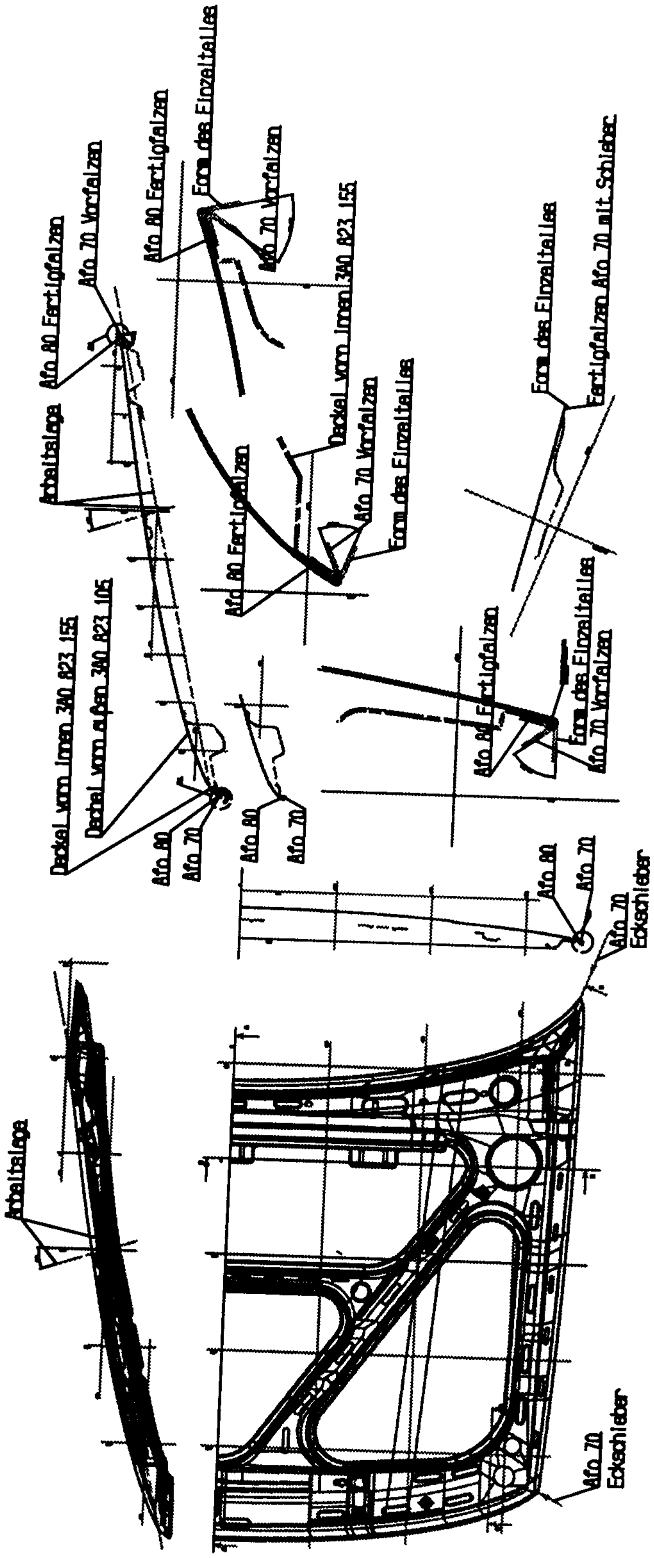


Figure 5.3.13-4: Technical drawing representing the fold plan of the outside panel

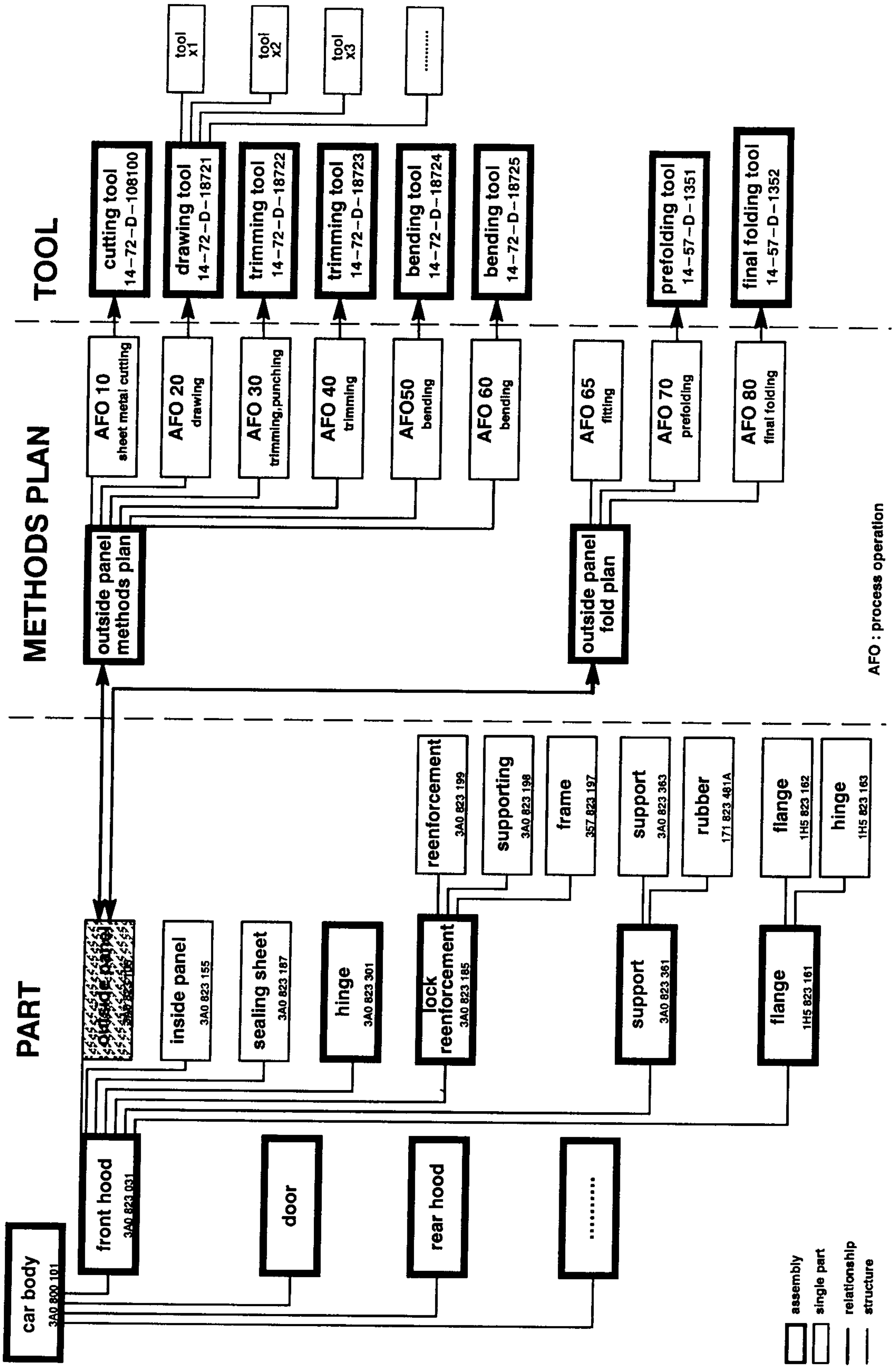


Figure 5.3.13-5: Complete structure of the example VW Passat front hood, outside panel

5.3.13.3 Mapping to the AP214 ARM

terminology of application experts	AP 214 application object	UoF
part (examples: Car body, front hood, door, rear hood, outside panel, inside panel, sealing sheet)	part	S1
tool (examples: Cutting tool, drawing tool, trimming tool)	tool	S1
assembly component constituents (examples: Car body, front hood)	next_higher_assembly	S2
corresponding tool	part_tool_relationship p_o_tool_assignment	S5
process operation (AFO) (examples: Sheet metal cutting, drawing, bending, trimming, fitting, prefolding)	process_operation	
process plan methods plan (examples: fold plan)	process_plan	
3D-surface model	surface_model	G3
technical drawing	drawing	D1, D2
3D-surface model	surface_model	G3

Figure 5.3.13-6: Terminology of application experts

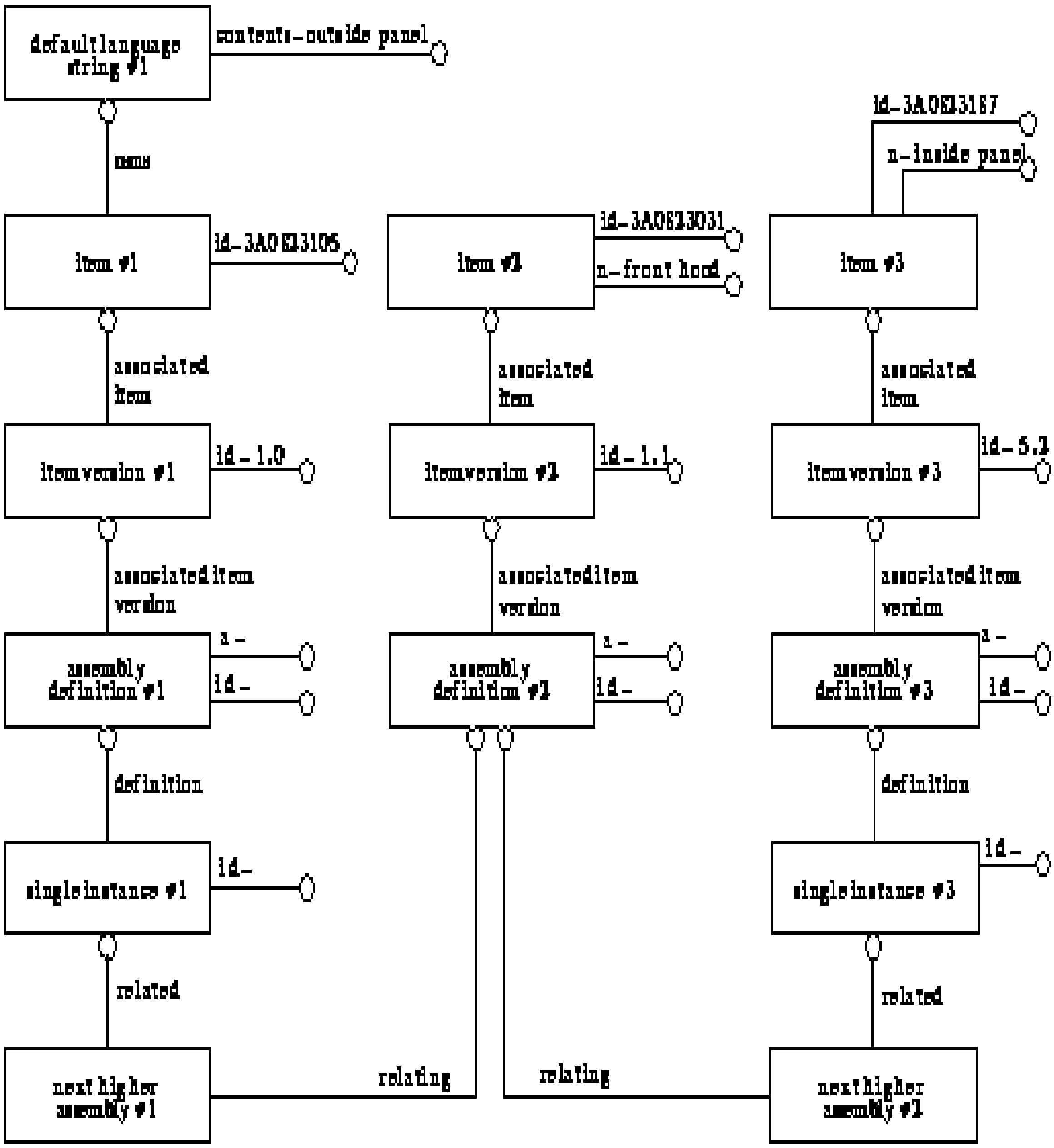


Figure 5.3.13-7: Instantiation of product structure

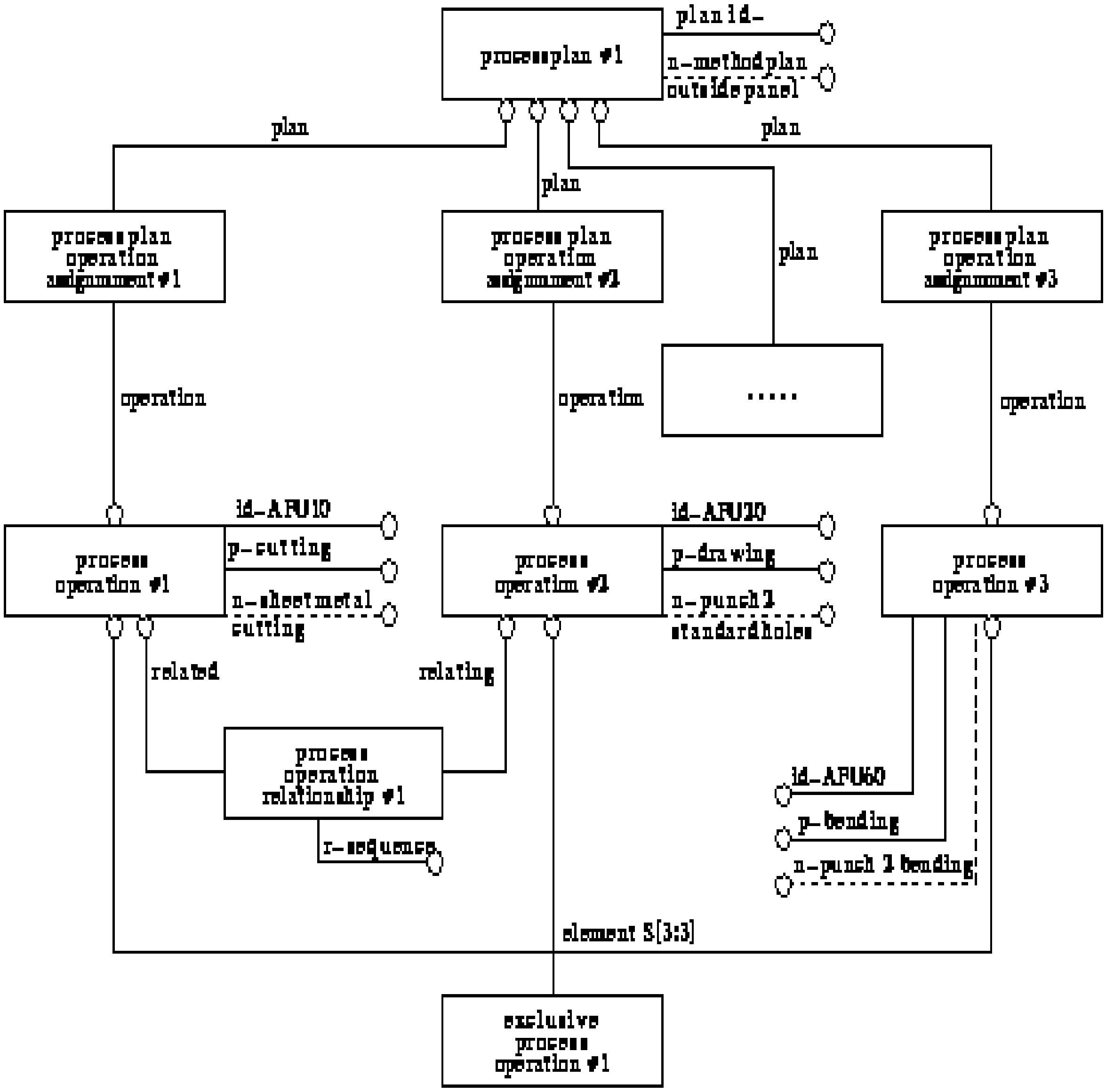


Figure 5.3.13-8: Instantiation of process_plan

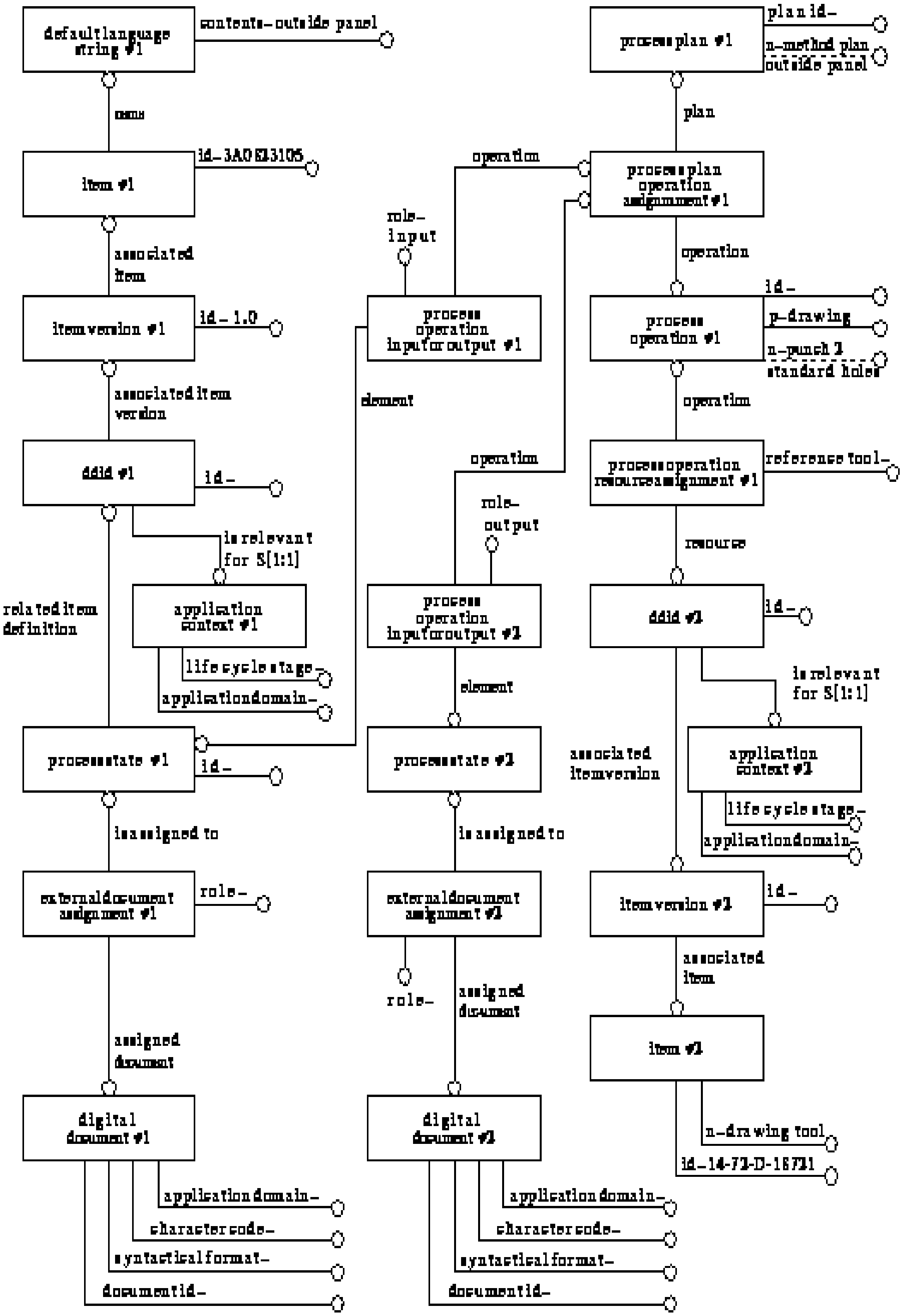


Figure 5.3.13-9: Instantiation of part_tool_relationship

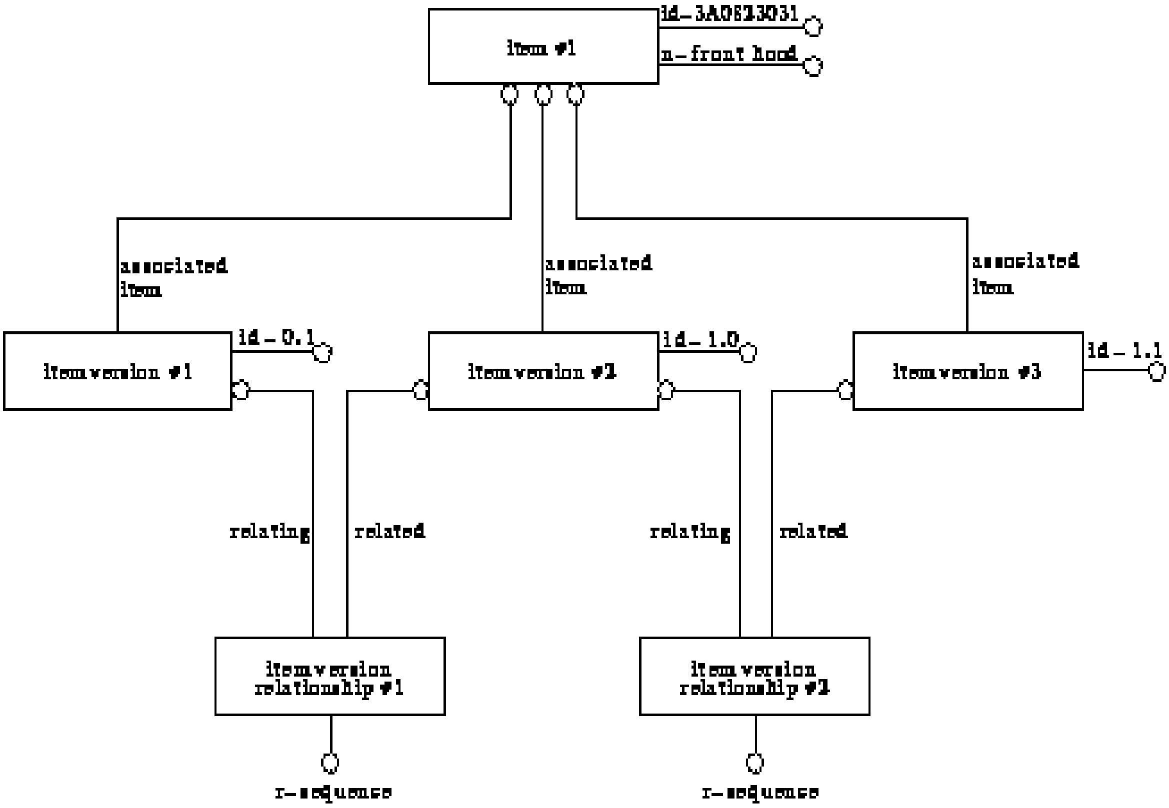


Figure 5.3.13-10: Instantiation of versioning

5.3.13.4 Discussion

The population of the structures of the AP214 ARM with the data of the example showed, that the requirements of this example are completely met. No issues have been derived from the example.

5.3.14 ZF: Shift Mechanism for 6-Speed Transmission

Owner: Rudolf Hummel, ZF Friedrichshafen AG, Germany

Date: January 27, 1997

Referenced document: ISO TC184/SC4/WG3/N536

5.3.14.1 Abstract

This example deals with the description of an assembled shift actuation for two gears.

5.3.14.2 User description

The illustration shows the shift actuation for two gears.

The selector rail 06.500 and selector lever 06.510 are used to displace the driver device 06.410 and shift rail 06.400.

This causes the shift fork to rotate around the pins 06.510. The fulcrum pads 06.440 move the sliding sleeve /140 into mesh with the clutch body of the gear 03.030 or the mating gear. The switch 06.560 shows the respective position of the selector device by means of an electronic display unit.

The detent 06.440 holds the shift device in its respective position and prevents any vibrations.

The selector rail is actuated by a further driver device when the vehicle operator moves the shift lever. At this point, the selector rail rotates (to engage with the driver device) and is moved along (gearshift).

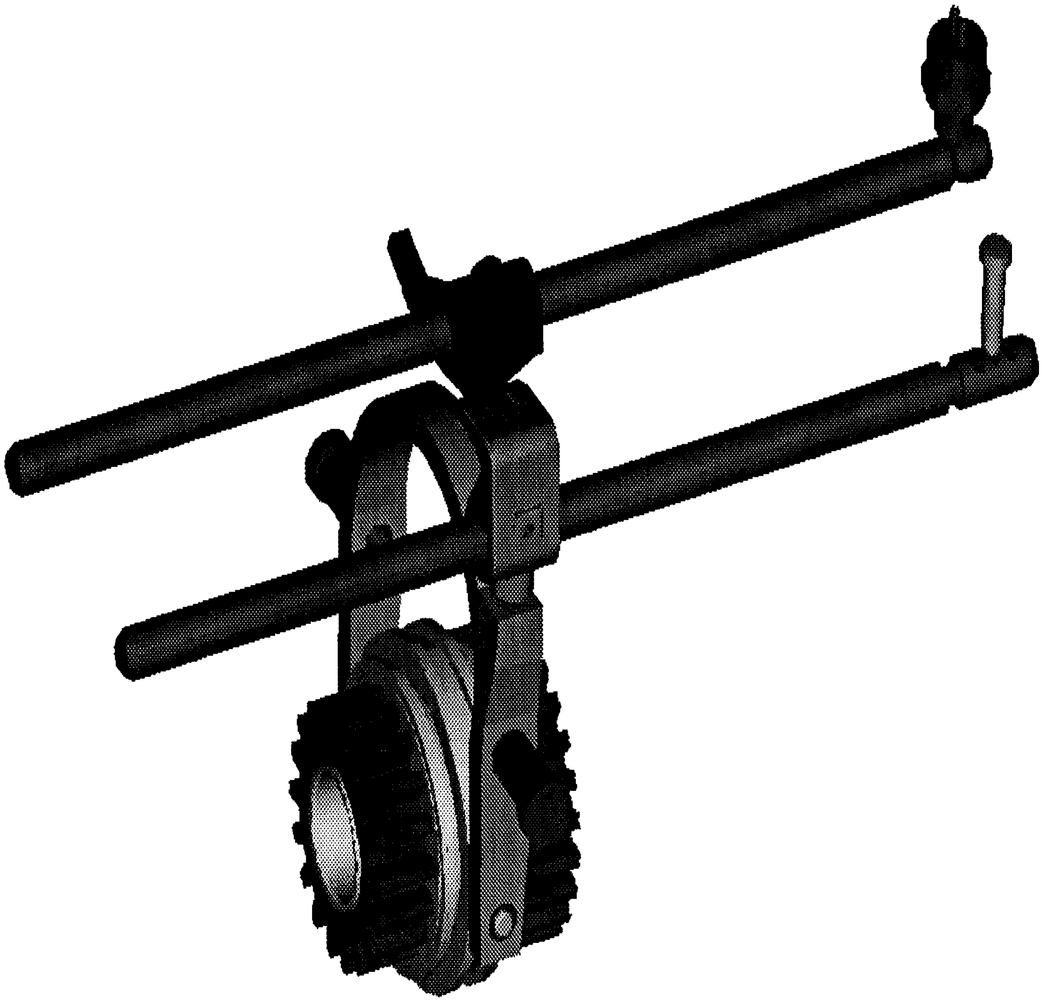


Figure 5.3.14-1:   Shift mechanism

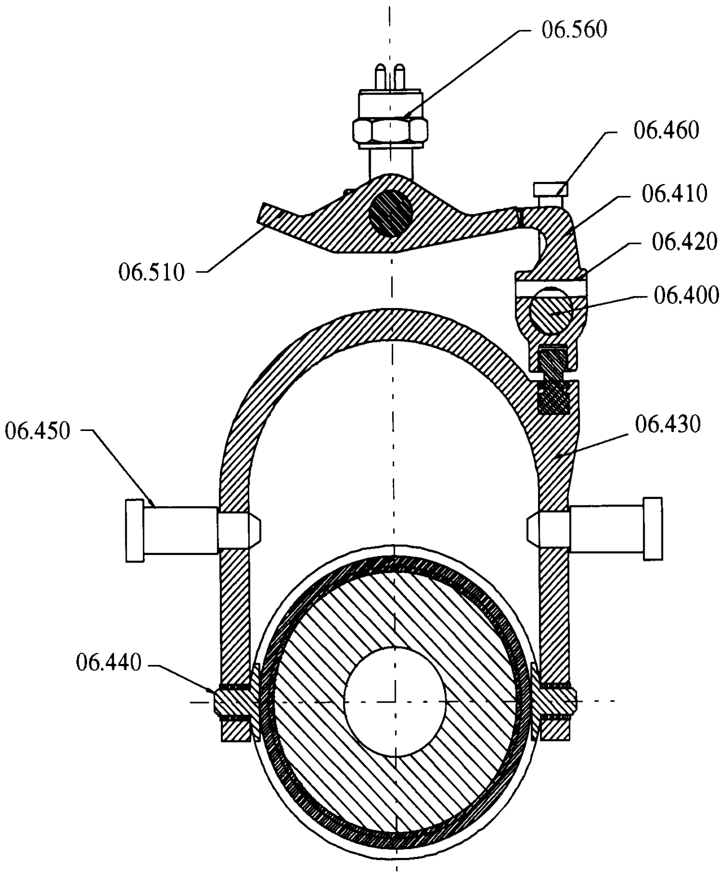


Figure 5.3.14-2: Sectional view on shift mechanism - front

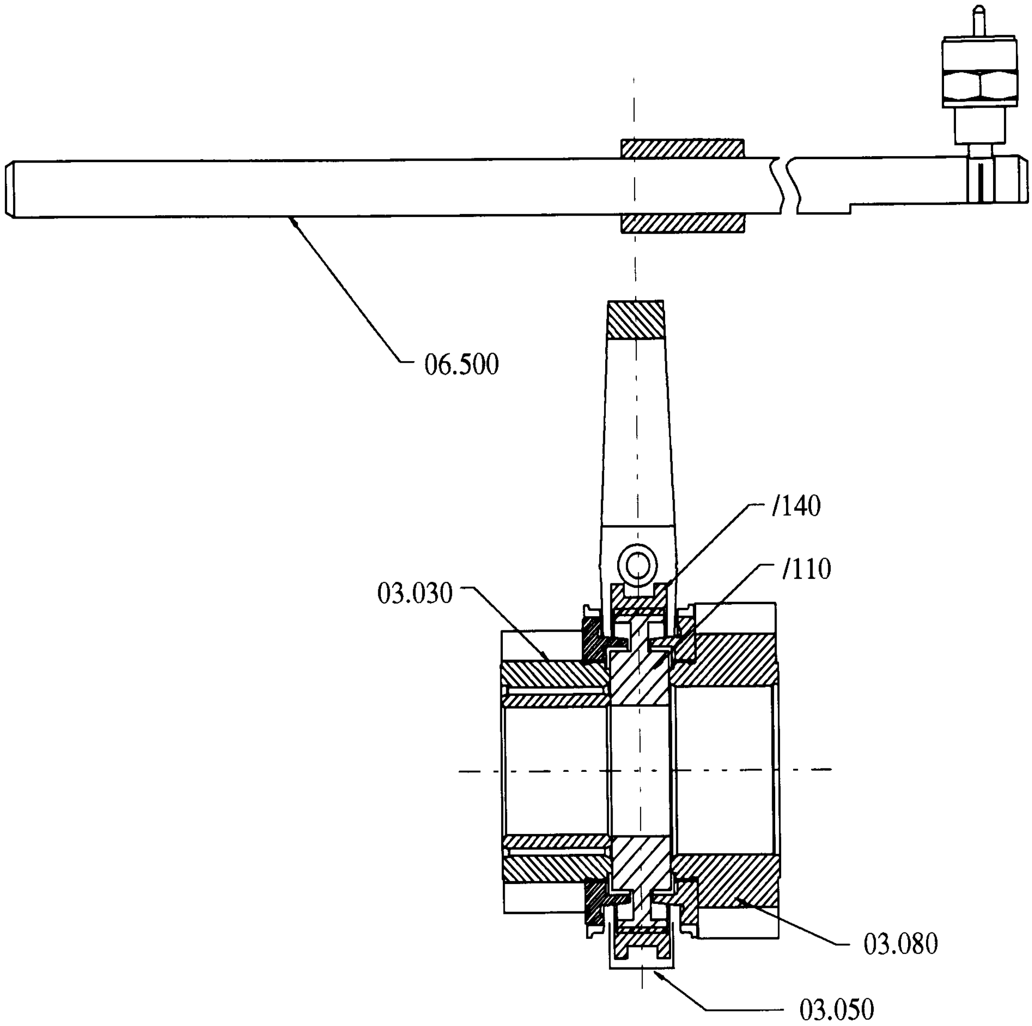


Figure 5.3.14-3: Sectional view on shift mechanism - side

5.3.14.3 Mapping to the AP214 ARM

The mapping of relevant information to the AP214 ARM is done in the area of UoF's product_management_data (S1), item_definition_structure (S3), and external_reference_mechanism (E1).

The components of the gear shift are related to the assembly by next_higher_assembly. Where available, information on a digital document (CAD model describing the component) is attached to the related single_instance. The physical_instance on top level represents the product as delivered to the customer.

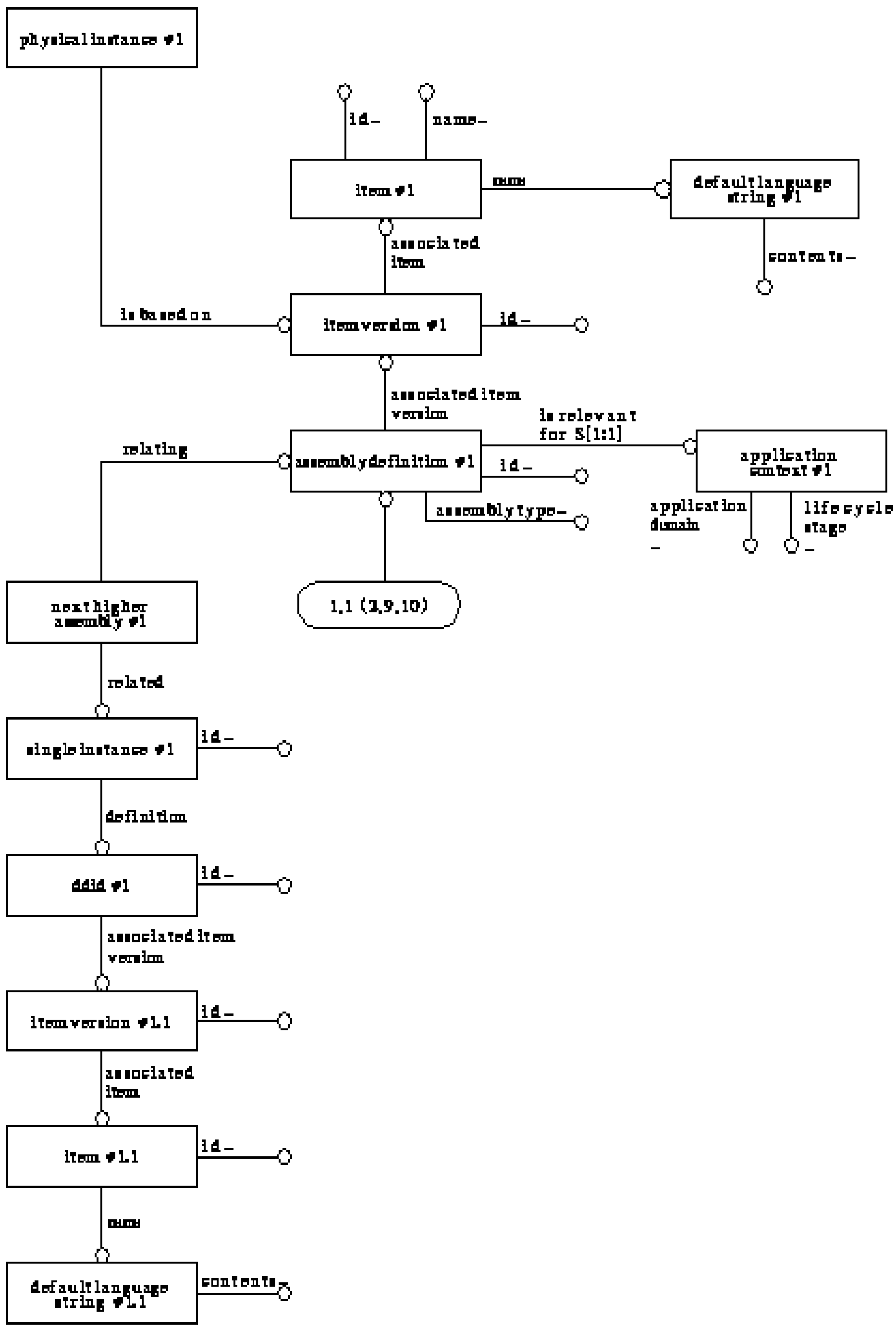


Figure 5.3.14-4: Mapping of gear shift to ARM - 1

5.3.14.4 Discussion

No issues concerning the ARM of AP214 have been derived from the example.

6 Integrated resources interpretation

Activities for the review of the AIM took place at five workshops dedicated on AP214 mapping and one workshop where the AIM was reviewed with regard to other APs with overlapping requirements (see Table 6-1). There the AIM was reviewed and evaluated with regard to the mapping of the ARM requirements to the Integrated Resources. The participants were modelling and integration experts from debis Systemhaus GmbH (Germany), DiK (Technical University of Darmstadt, Germany), Grumman Data (USA), PDIT (USA), PDES (USA), RPK (University of Karlsruhe, Germany) and ProSTEP GmbH (Germany). For technical questions several user experts joined the teams for relevant discussions.

Workshop	**Meeting**	**Date**	**Comment**
AP214 Mapping workshop	Long Beach, USA	06/1994	first CD version of AP214
AP214 Mapping workshop	Charleston, USA	10/1994	first CD version of AP214
AP214 Mapping workshop	Darmstadt, Germany	02/1995	first CD version of AP214
AP214 Mapping workshop	Stuttgart, Germany	05/1996	second CD version of AP214
Interoperability Workshop	Darmstadt, Germany	08/1996	backbone, PDM schema
AP214 Mapping workshop	Stuttgart, Germany	08/1996	second CD version of AP214

Table 6-1: Mapping Workshops

With these workshops and the additional interoperability discussions on the ISO TC184 SC4 WG meetings a complete coverage of the AP214 mapping was achieved.

7 AIM Validation

With implementations the qualification of the standard - especially the AIM - can be evaluated. Furthermore early feedback from implementation experiences may influence the specification even in the ARM towards a more applicable standard. Two classes of systms were in focus for the implementations: The CAD systems and the PDM systems. The CCs relevant for the CAD systems are AP214 CC1 (product identification, geometry with presentation, and model structures), CC2 (product structure with assemblies, geometry with presentation, and model structures), and CC6 (draughting).

7.1 ProSTEP Prototypes

Due to the fact, that the AIM of AP214 has not been available during the ProSTEP Project (1991 - 1993) the ProSTEP Integrated Model Schema (PIMS) has been defined to be the basis for the prototype implementations of the project. The scope of the PIMS has been restricted to a subset of the AP214 and the specified EXPRESS-Schema represents relevant entities of the integrated resources that will be part of the AP214 AIM. The specification has been harmonized with the development of AP214 in general and with AP201, AP202 as well as AP203 in detail. Therefore the ProSTEP Integrated Model Schema can be regarded as a 'preliminary AIM' of AP214.

The ProSTEP Integrated Model Schema has been the basis for four kinds of prototype implementations:

- Processors for the exchange of basic structure data (product, product_version, group, layer),
- for the exchange of geometry data (wireframe_3D, shell_based_surface_model, advanced_Brep),
- for the exchange of draughting data and
- database implementations for the management of product and tool database.

The experiences gained by the implementations has been an important feedback to the AP214 specifications.

7.1.1 ProSTEP Integrated Model Schema (PIMS)

This ProSTEP Integrated Model Schema (PIMS) specifies the extracts from the integrated resources necessary for the scope and information requirements for the implementations to be made within the ProSTEP project.

PIMS was the first version of a subjective data model which connects different model representations under an overall product structure. It was designed to be easy extendable according to the requirements of the application context of the future AP 214 'Core Data for Automotive Mechanical Design Processes'.

The ProSTEP--IMS consists of the following parts:

1. Product Structure
2. Shape
3. Presentation

4. Draughting

The part 'Product Structure' is the common basis for the integration of different product description data. A so-called 'entry level' of this was required by all implementations to ensure compatibility. Additionally the implementations could combine different levels of the parts 'Shape' and 'Presentation' or 'Draughting'.

7.1.2 Implementations of PIMS

Wheras the database implementations of the PIMS were restricted to preliminary prototypes, the implementation of CAD processors based on the PIMS geometry schema made good progress. Implementations could be demonstrated for advanced_breps, CSG, facetted_brep, surfaces, and wireframes. The following system vendors joined the implementation activities:

- Autodesk : Autocad
- Control Data : ICEM DDN
- Computervision : CADDS
- debis Systemhaus : CATIA
- EDS : Unigraphics
- Hewlett Packard : HP/PE Solid Designer
- Intergraph : I-EMS
- Matra Datavision : Euclid 3
- Mercedes Benz : Syrko
- SDRC : I-DEAS
- Siemens Nixdorf : STEP Integrator
- Tebis : Tebis-NC
- Tecnomatix : Robcad

The problems and results were continiously discussed at the ProSTEP round table by the system vendors mentioned above.

7.2 Further Implementations

7.2.1 CC1 based Implementations

After release and distribution of AP214 CD version in August 1995, the first official AP214-CC1 schema was handed out. The data model contained in the schema allowed for mapping of information on

- product management data (S1),
- element structure (S2),
- 3D wireframe (G2),
- surfaces (G3),
- facetted b-reps (G4),
- advanced b-reps (G5),
- CSGs (G7), and
- geometric presentation (P1).

Participants on the ProSTEP Round Table shifted their implementations from PIMS to CC1 schema within four months.

Up to now three official CC1 schemas (based on the first CD version of AP214) had been distributet:

- August 1995
    - extracted from CD document
    - no object identifier defined
- April 1996:
    - reworked schema
    - object identifier: { 1 2 10303 214 -1 1 3 3 }
- November 1996
    - inclusion of types needed for colouring of geometry
    - object identifier: { 1 2 10303 214 -1 1 3 4 }

Implementations based on CC1 were done by:

- Alias|Wavefront : Autostudio

- debis : CATIA
- Computer Vision : CADDS
- Dassault Systemes : CATIA
- EDS : Unigraphics
- HP/CoCreate : SolidDesigner
- Intergraph : EMS
- MATRA : Euclid and STRIM
- Mercedes Benz : Syrco
- Parametric Technology : Pro/Engineer
- SDRC : I-DEAS

7.2.2 CC2 based Implementations

In parallel to CC1 CC2 schemas were distributed. Additionally the schema allows for mapping of information on

- assemblies (S3), and
- external references (E1).

The three official CC2 schemas are as follows:

- August 1995
    - extracted from CD document
    - object identifier: { 1 2 10303 214 -1 1 5 1 }
- April 1996:
    - reworked schema
    - object identifier: { 1 2 10303 214 -1 1 5 2 }
- November 1996
    - inclusion of types needed for colouring of geometry
    - object identifier: { 1 2 10303 214 -1 1 5 3 }

Implementations based on CC2 were done by:

- Alias|Wavefront : Autostudio
- debis : CATIA

- Dassault Systemes : CATIA
- EDS : Unigraphics
- HP/CoCreate : SolidDesigner
- Parametric Technology : Pro/Engineer

7.2.3 Validation of Processor Implementations

The processor implementations based on AP214 have been validated by several Test Rallys held by ProSTEP, Germany, PDES, Inc, USA and by several Benchmarks held by ProSTEP Association, Germany.

7.2.3.1 First Test Rally

The first Test Rally in October 1995 focused on 'simple geometry'. Therefore synthetic test cases, containing simple geometry elements, had been defined. The advantage of non-complex test models was the detection of errors in implementations with less effort than needed other ways.

The figures below show examples of the used test cases:

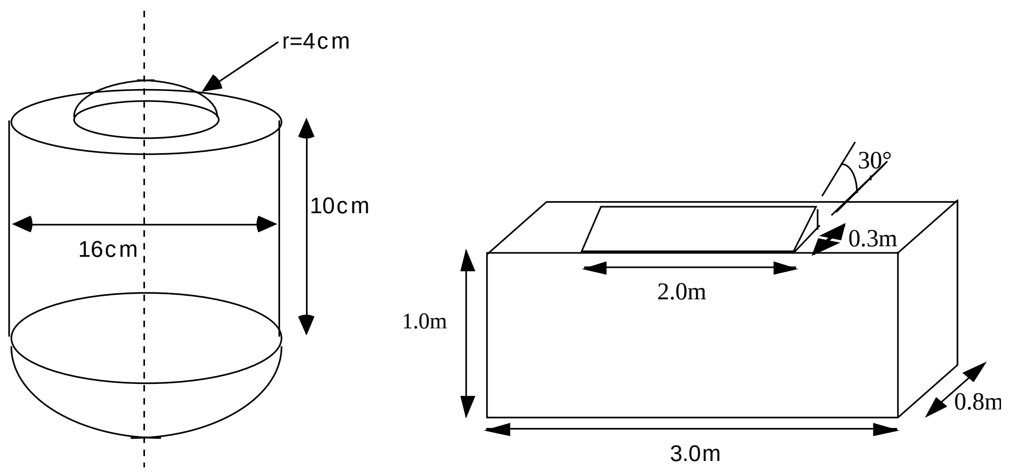


Figure 7.2.3-1: Cylinder and block object

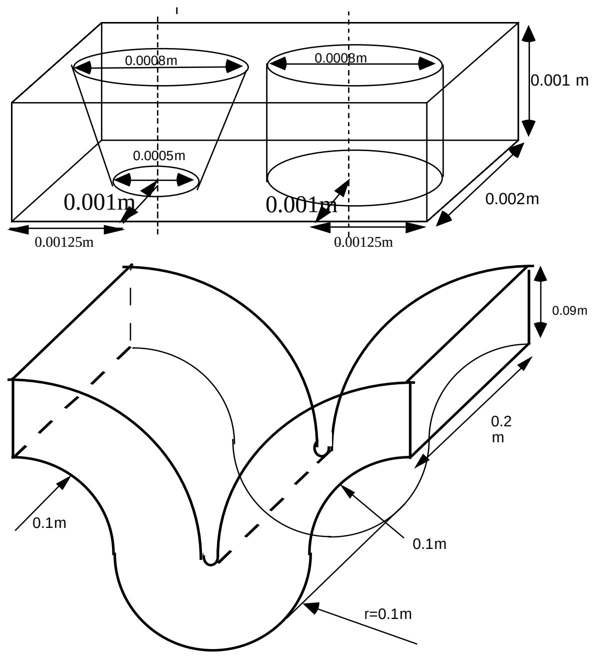


Figure 7.2.3-2: Block object with holes and sweep opject

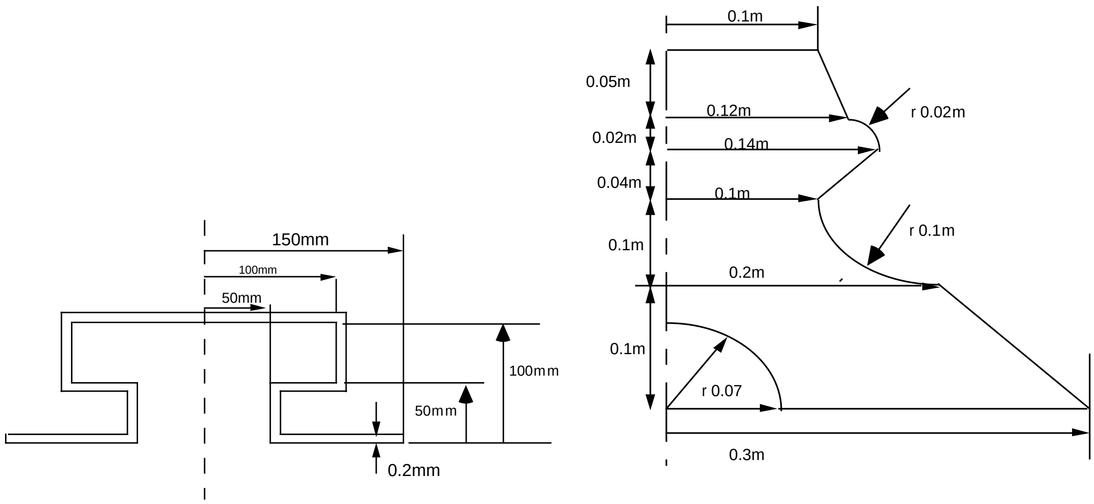


Figure 7.2.3-3: Sweep and revolution object

7.2.3.2 Second Test Rally

The second Test Rally in February 1996 focused on 'advanced implementation of geometry', meaning geometry and assembly structures. Therefore synthetic test cases had been combined with real-world models, provided by several users.

The figures following are a subset of the test cases used within the Test Rally:

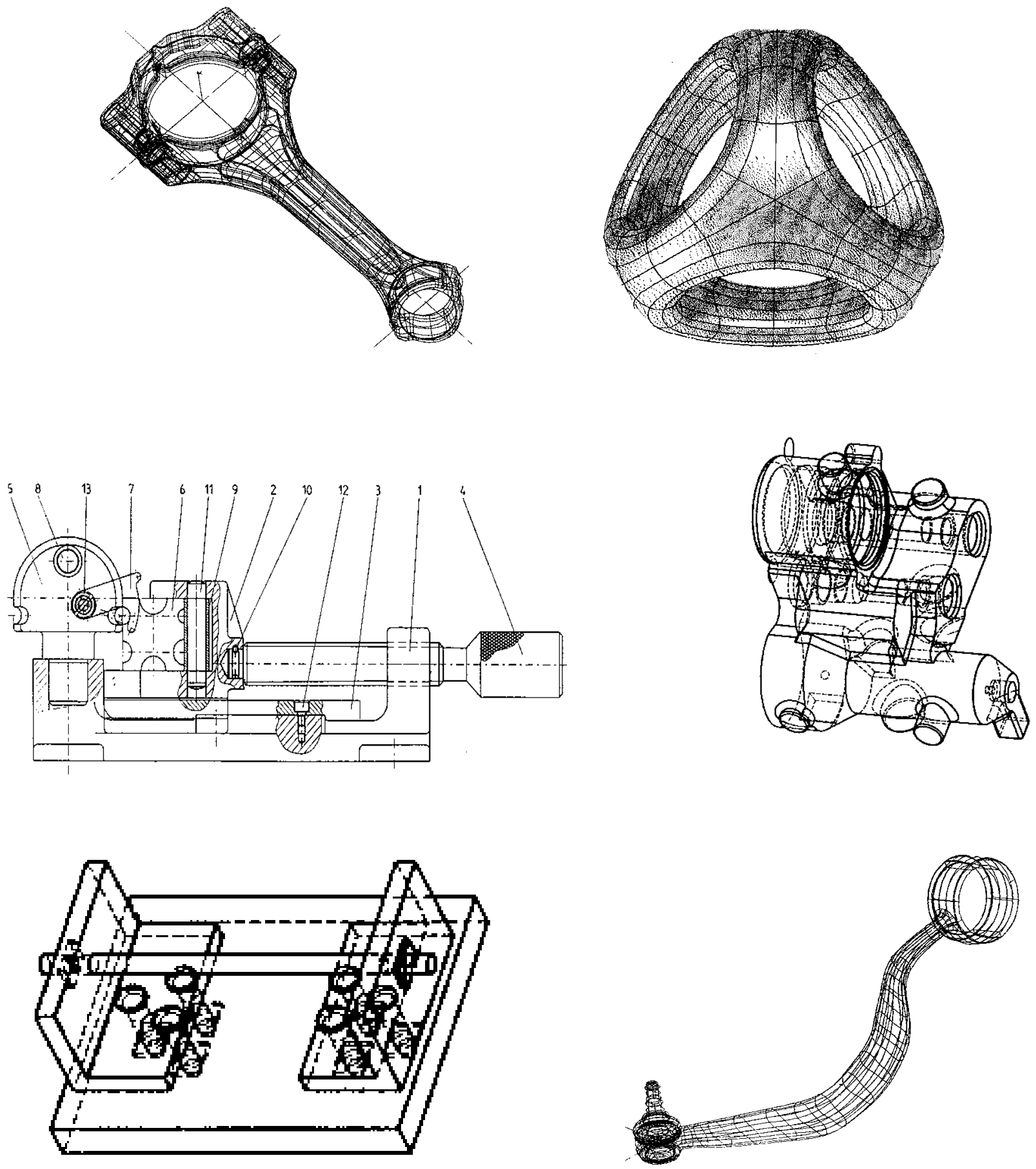


Figure 7.2.3-4: Test cases used within the second Test Rally

7.2.3.3 Third Test Rally

The goals of the third Test Rally in June 1996 had been defined as:

- solid models,
- assemblies, and
- surface models.

The figures showed in following are a subset of the test cases used within the Test Rally:

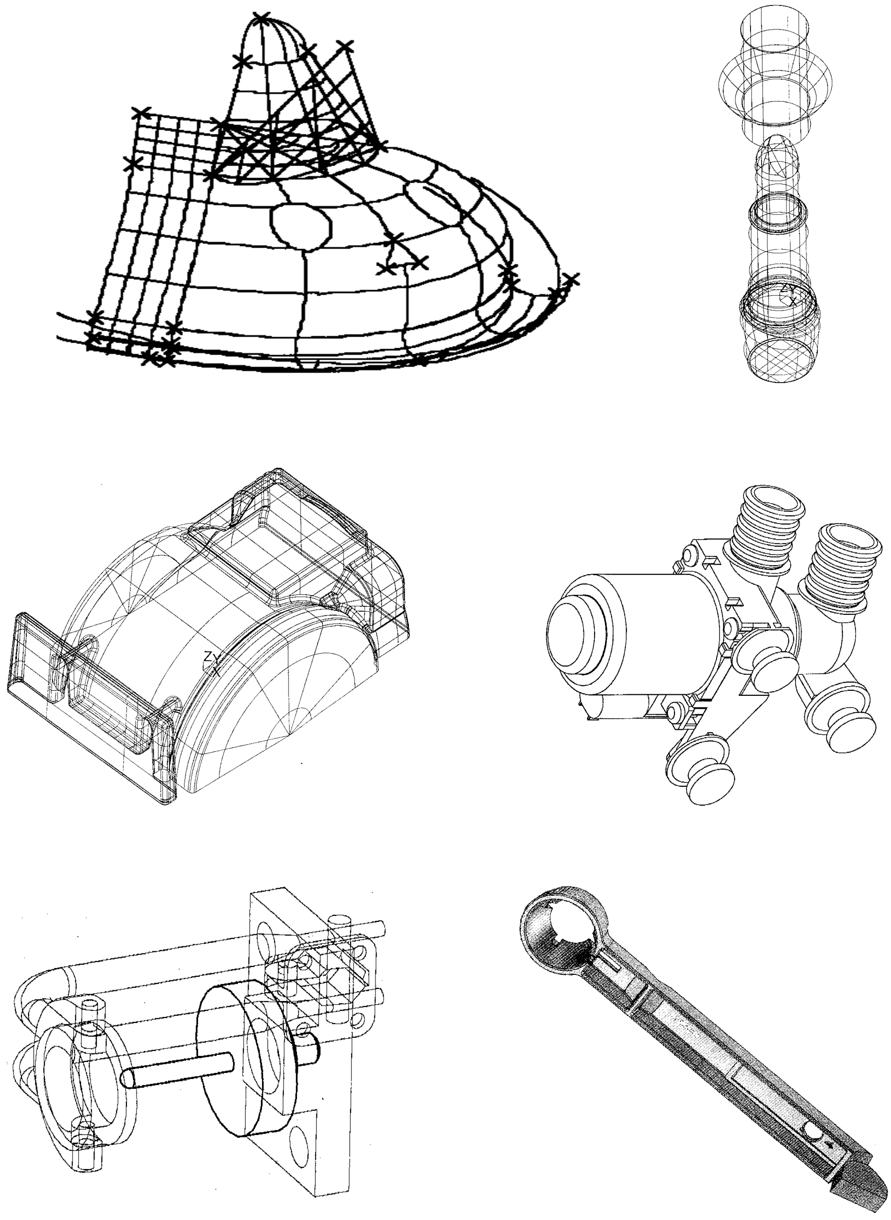


Figure 7.2.3-5: Test cases used within the third Test Rally

7.2.3.4 Fourth Test Rally

The goals of the fourth Test Rally in November 1996 had been defined as:

- solid models,
- assemblies,
- surface models, and
- presentation.

The figures showed in following are a subset of the test cases used within the Test Rally:

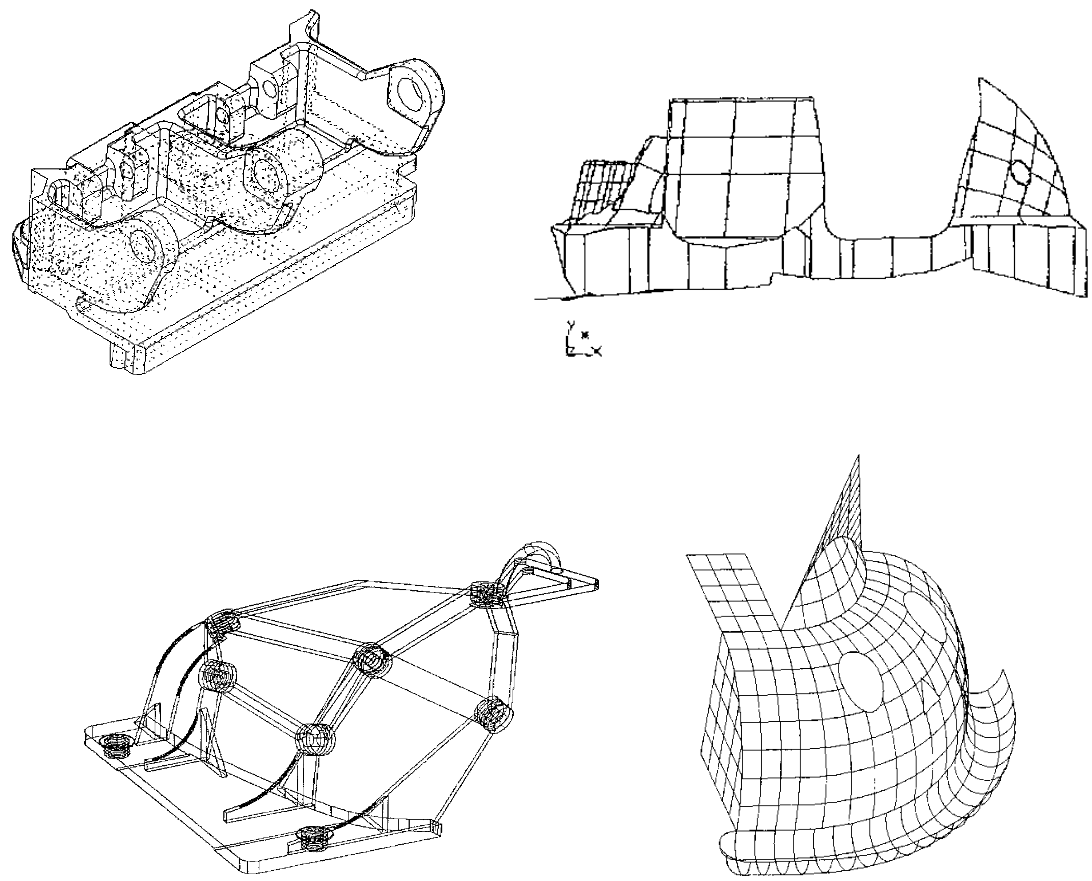


Figure 7.2.3-6: Test cases used within the fourth Test Rally

7.2.3.5 Fifth Test Rally

The goals of the fifth Test Rally in February 1997 were the same as defined for the fourth Test Rally. More intensive testing should be done in the geometric presentation area.

The figures showed below are a subset of the test cases used within the Test Rally:

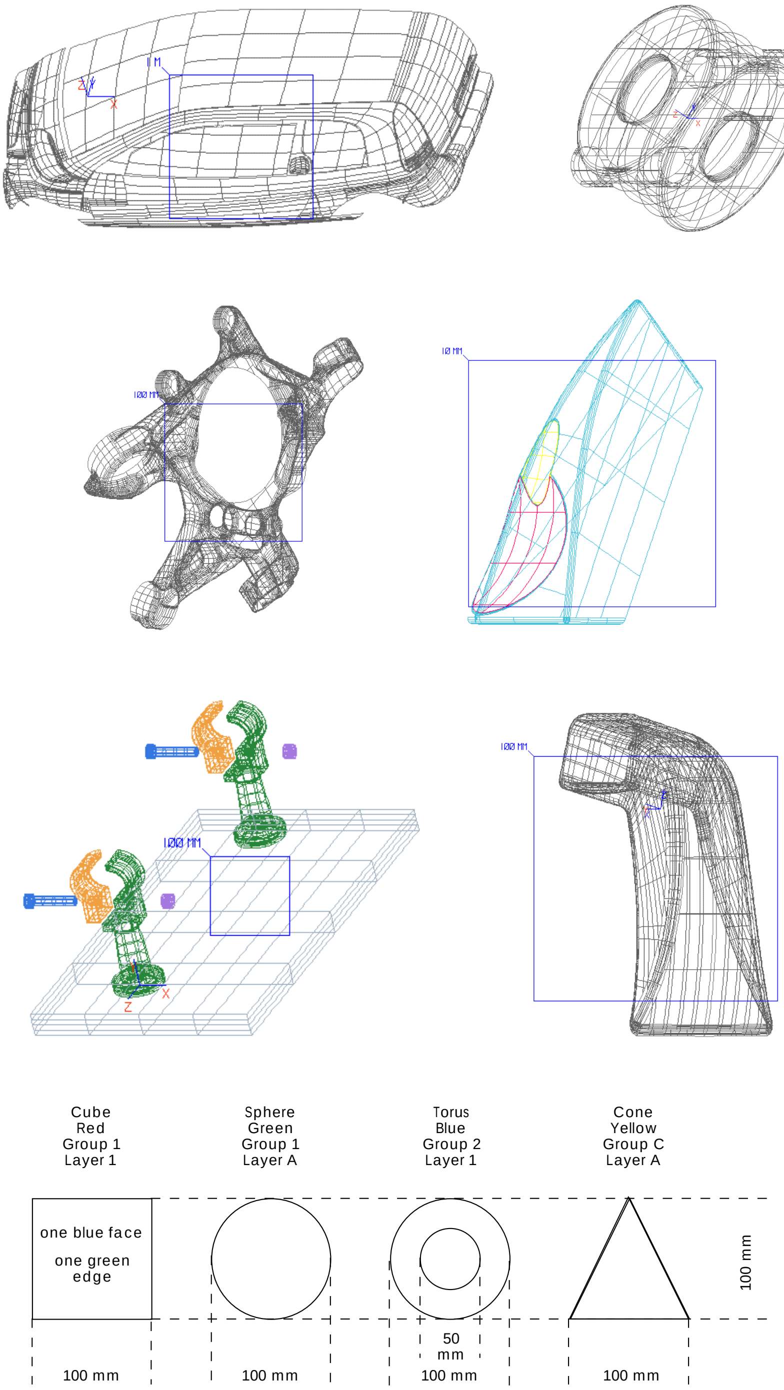


Figure 7.2.3-7: Test cases used within the fifth Test Rally

7.2.3.6 Sixth Test Rally

The goals of the sixth Test Rally in June 1997 were in the area of big, substantial, coloured models as well as hybrid models. The figures showed below are a subset of the test cases used within the Test Rally:

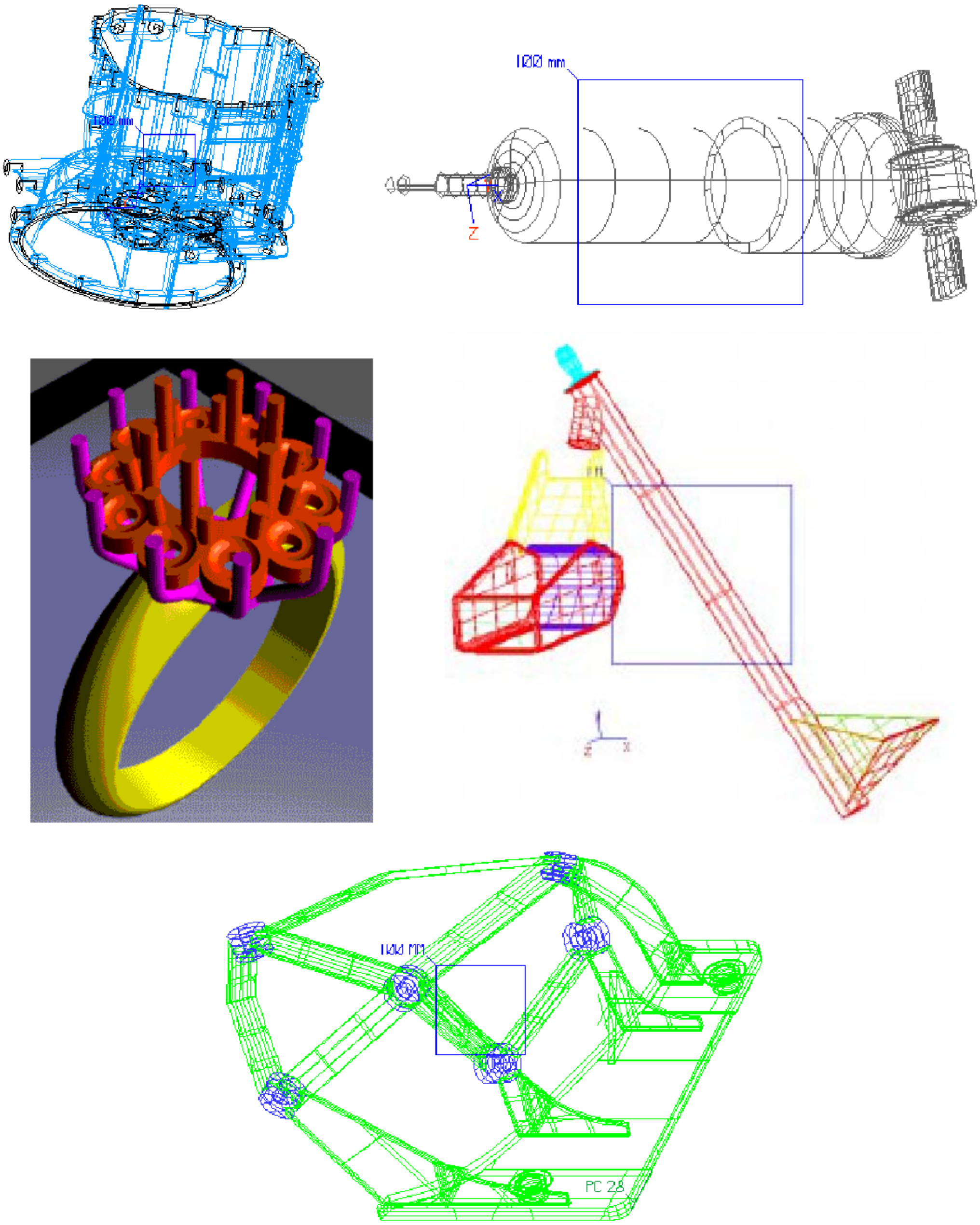


Figure 7.2.3-8: Test cases used within the sixth Test Rally

7.2.3.7 Seventh Test Rally

The goals of the seventh Test Rally in October 1997 were the area of instance naming, hybrid model testing as well as re-test of Test Rally No. 1 models.

7.2.3.8 Eighth Test Rally

The figures showed below are a subset of the test cases used within the Test Rally:

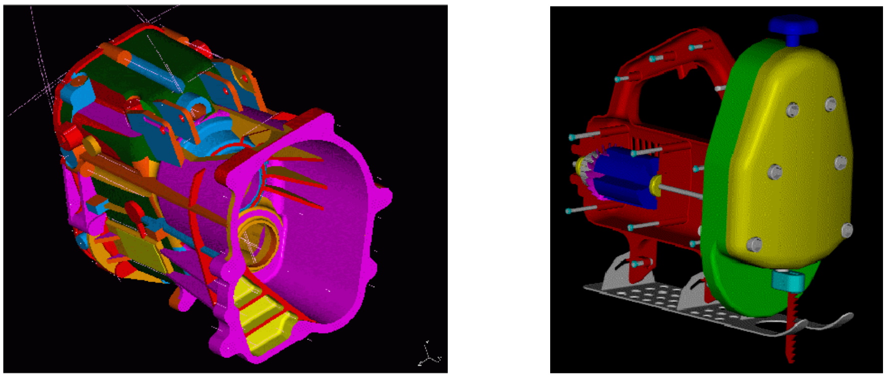


Figure 7.2.3-9: Test cases used within the eighth Test Rally

7.2.3.9 Nineth Test Rally

The figures showed below are a subset of the test cases used within the Test Rally:

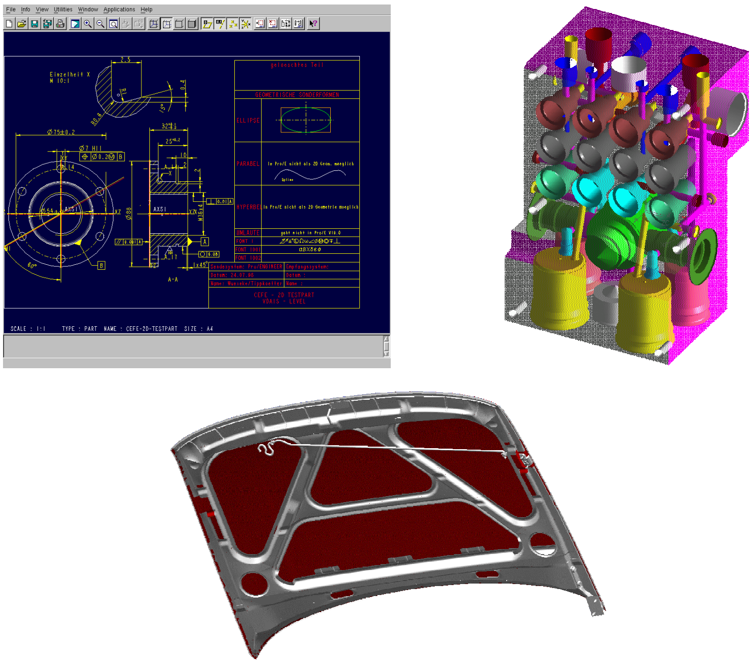


Figure 7.2.3-10: Test cases used within the nineth Test Rally

7.2.3.10 CAx Implementor Forum Test Rallys

The CAx Implementor Forum is the result of the merge of ProSTEP Implementor Round Table with PDES, Inc. STEPnet. Based on the aim of testing interoperability between AP214 and AP203 in geometry area, from beginning of 1999 Test Rallys were based on AP214 schema with focus in year 2000 on PDM core data (product identification, product structure), geometry, colours, form features, external references and associative texts.

The 3rd CAx Implementor Forum Test Rally was conducted Q1/2000. Participants were:

AutoDesk	Bentley
debis	Dassault Systemes
UG Solutions	ITI/SDRC
PTC	STEP Tools Inc.
Matra	Theorem Solutions
ITI/CADDS	Alias|Wavefront

Focus of the Test Phase was on

- Validation Properties,
  - *Area,*
  - *Volume,*
  - *Centroid,*
- Colors,
  - *Overriding Edge Color,*
  - *Overriding Face Color,*
  - *Solid Color,*
- 3D Text Annotation,
- Drawing Views,
- Features (Round Hole and Threaded Hole), and
- Production Models.

The following pictures show the collection of CAD-Models tested in the Test Rally.

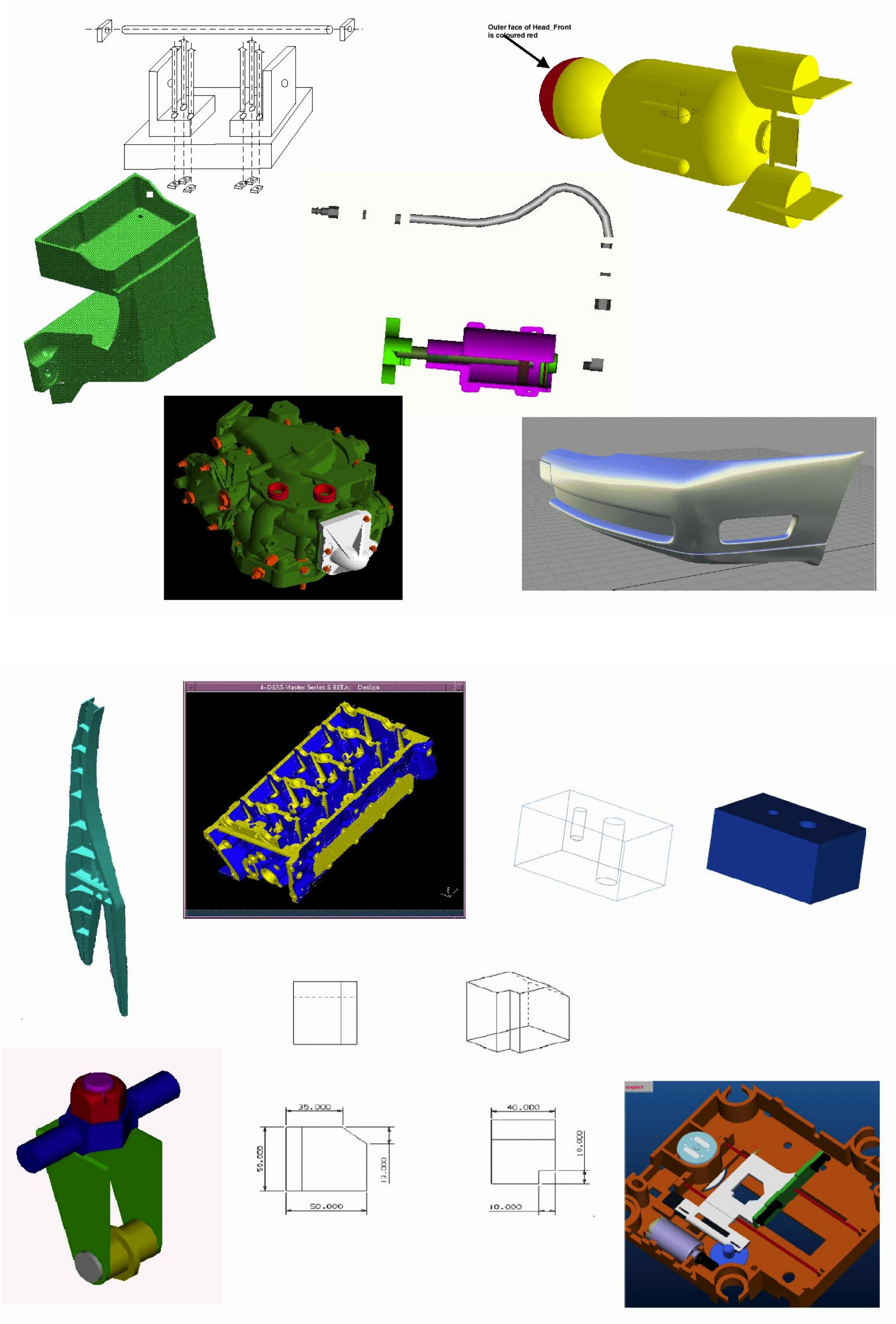
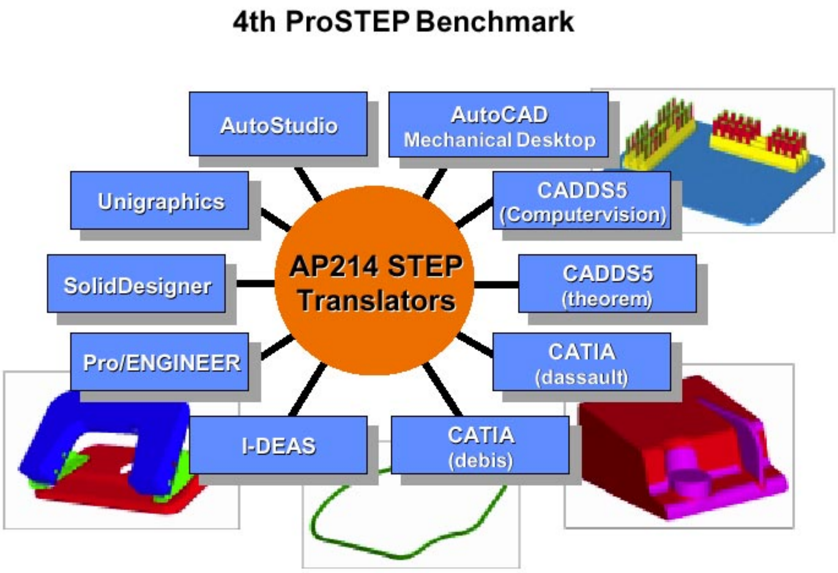


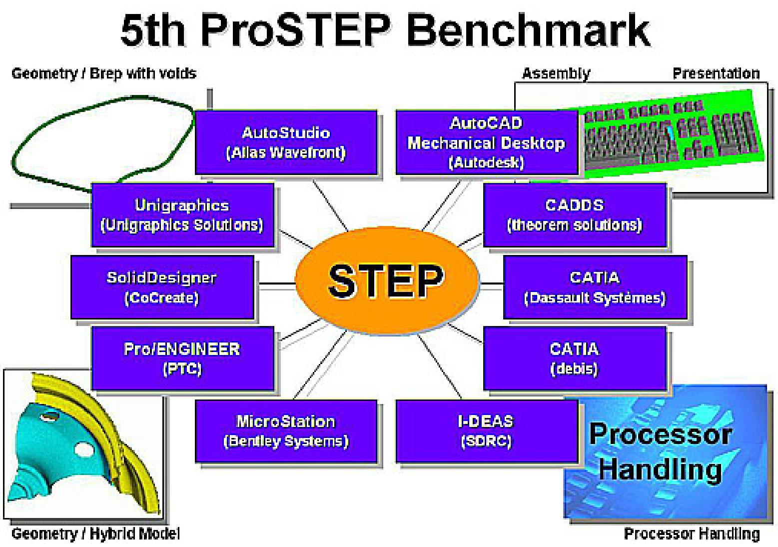
Figure 7.2.3-11: Test cases used within the 3rd CAX Implementor Forum Test Rally

7.2.3.11 ProSTEP Benchmarks

Goal of the ProSTEP Benchmarks is the check of STEP-based data exchange software concerning scope of functionality, stability, quality of exchange result and processor handling.

Up to now 5 Benchmarks with different scopes have been conducted (see graphics below).





8 Conformance Requirements Evaluation

Based on the result of the 13 evaluations done on ARM level (see also chapters 4 and 5), which was done taking the Conformance Class (CC) definitions into account, it was proofed that the definition of CCs match the user requirements.

AP214 UoFs	Example	1	2	3	4	5	6	7	8	9	10	11	12	13
S1	Product_management_data	X	X	X	X	X	X	X	X	X	X	X	X	X
S2	Element_structure	X												
S3	Item_definition_structure	X		X	X							X		X
S4	Effectivity	X						X				X		
S5	Work_management	X					X		X			X		
S6	Classification	X				X						X	X	
S7	Specification_control	X				X	X				X	X		
S8	Process_plan			X	X									
G1	Wireframe_model_2D													
G2	Wireframe_model_3D													
G3	Connected_surface_model				X									
G4	Faceted_B_rep_model													
G5	B_rep_model		X							X				
G6	Compound_model		X							X				
G7	CSG_model													
G8	Geometrically_bounded_surface_model													
MD1	Measured_data													
PR1	Item_property	X		X										
P1	Geometric_presentation													
P2	Annotated_presentation				X									
P3	Shaded_presentation													
D1	Explicit_draughting													
D2	Associative_annotation				X									
K1	Kinematics													
FF1	User_defined_feature		X							X				
FF2	Included_feature		X							X				
FF3	Generative_featured_shape		X							X				

AP214 UoFs	Example	1	2	3	4	5	6	7	8	9	10	11	12	13
C1	Surface_condition		**X**											
T1	Dimension_tolerance		**X**											
T2	Geometric_tolerance		**X**											
E1	External_reference_mechanism												**X**	**X**

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